EXPLORING THE INTERACTIVE AND LINGUISTIC DIMENSIONS OF PARENT INPUT AND THEIR ROLE IN THE DEVELOPMENT OF CHILDREN'S SIMPLE SENTENCES

BY

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THESIS

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ABSTRACT

Research investigating how parent input influences child language outcomes has typically analyzed input from the perspective of only one dimension at a time. Rowe and Snow (2020) proposed an alternative framework for analyzing input from a multi-dimensional perspective, integrating the interactive, linguistic, and conceptual dimensions to better identify high-quality input for a defined developmental period. The purpose of this study was to identify how different features from the interactive and linguistic dimensions intersect in parent input at 21 months, and how those intersections relate to the production of diverse, childlike simple sentences at 30 months. *Optimal input* was defined as responsive and contextualized simple active declarative sentences. Twenty naturalistic parent-child observations at 21 months were coded for their linguistic and interactive features in parent input. In addition, child sentence diversity was calculated at 30 months. Results indicated that at 21 months, *optimal input* was rare, while responsive parent input that was not linguistically ideal, and parent input that was neither responsive nor linguistically ideal were relatively common. Partial correlations, controlling for the total number of parent utterances, were used to examine relations between parent input and child sentence diversity. *Optimal input* was not related to child sentence diversity at 30 months; however, parent input that was *neither* responsive nor declarative was negatively correlated with child sentence diversity. Future clinical research should continue to explore parent input from a multi-dimensional perspective to determine what is optimal or less helpful for clearly defined developmental periods.

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CHAPTER 1: INTRODUCTION & LITERATURE REVIEW

The ability to learn language is one shared by virtually all children, with the most rapid period of growth occurring during the first five years. A central question to the field of language development is how children are able to acquire and master such a complex system in such a short period of time. Various theoretical frameworks have attempted to pinpoint the driving force behind language development, and many agree that linguistic input and a communication partner are crucial components children need to successfully learn their native language (cf. Hoff, 2006).

Although most researchers have acknowledged the importance of input in language learning, different theoretical frameworks have characterized the role of input in different ways. For example, the social-interactionist perspective of language learning emphasizes how social interactions support language development and motivate the child to communicate and connect with others (Bohannon & Bonvillian, 1997). Alternatively, frameworks motivated by generative linguistic theory have highlighted how input works with innate knowledge about linguistic structure to create generalizations about the child's native language (Chomsky, 1965).

Both theoretical frameworks have motivated important empirical research to identify how high-quality features of input support language learning; however, many researchers have only analyzed input from one of these perspectives. Inquiries focused on the effect of environmental features have not deeply examined the linguistic content of input sentences, and studies of linguistic input have not considered to what extent the environment was optimal for absorbing the input sentences presented. By only focusing on one element of input, researchers have not adequately identified how these separate and compatible features of input work together to facilitate language learning.

To address this limitation, Rowe and Snow (2020) propose a shift towards a multi-dimensional view of how input quality is defined. They identify three distinct features that have been shown to enhance the quality of input across different periods of language development: interactive, linguistic, and conceptual. Each feature is dynamic, meaning that its importance may vary based on the child's developmental period. Interactive input features characterize how a supportive and socially engaging language learning environment can facilitate acquisition. During infancy, interactive input features are especially important to motivate conversational attempts and maintain the child's attentional focus. Quality linguistic features of input make the meaning and structural features of a language salient to the child, and progressively become more complex as the child's linguistic system develops. Finally, conceptually supportive features emphasize the 'here and now' during the earliest periods of development, assisting the child's ability to map word meaning to objects and events in the physical environment. As the child develops, the conceptual features of input must become more challenging to support the child's transition to decontextualized talk.

Of particular interest to this study is the transition from words to simple sentences. This is a crucial stepping stone in language development, because it represents children's emerging knowledge of syntactic structure. By learning to combine a subject with a verb, children demonstrate the ability to formulate a basic clause, and utilize noun phrases and verb phrases to build sentences. Through these simple sentences, children are able to harness their knowledge of syntactic structure to communicate about their observations, ideas, and events with those around them. Despite this, developmental research has largely overlooked the emergence of simple sentences and the role that input plays in the transition from words to sentences (Hadley et al., 2017). Therefore, this thesis examined how input sentences composed of optimal interactive, linguistic and conceptual features support children's ability to produce simple sentences. This literature review will proceed by addressing the development of simple sentences, and outline interactive, linguistic, and conceptual features of input that are optimal for facilitating simple sentences. It will then identify limitations in previous studies that have focused on only one dimension of input and highlight the need for a multi-dimensional approach to define input quality in order to best characterize its effects on supporting language development.

The Development of Simple Sentences

The transition from words to simple sentences is a significant developmental milestone. Word combinations broadly begin to emerge no later than 24 months (Rescorla, 1989), with the earliest sentences emerging between 24 and 26 months of age (cf. Hadley, McKenna, & Rispoli 2018). By 24 months, children typically develop a robust vocabulary comprised of a variety of word classes including nouns and verbs, and begin producing childlike simple sentences, combining a noun phrase with a verb phrase to form a basic clause (Hadley, Rispoli, & Hsu, 2016). This is a critical stepping stone in language development because not only is the basic clause the most fundamental unit of syntax, but the ability to produce sentences enables the child to express a wide array of topics. Also, childlike simple sentences bridge the developmental periods of word combinations and morphosyntactic development (Hadley, 2006). For example, a child must first formulate '*dog eat'*, before they can begin to use morphemes that encode language-specific grammatical features on top of this basic sentence structure to say, '*The dog is eating.'*

Despite its status as an important developmental stepping stone, simple sentence development has been historically overlooked by researchers in the field (Hadley et al., 2017). Although there are clear developmental expectations for the growth of vocabulary and grammatical morphemes, few studies have investigated a child's transition to simple sentences. Many clinicians and researchers have looked to Brown's early stages of grammatical development (1973) to characterize language growth in young children. Brown identified five stages of language development based on the mean length of utterance (MLU) and emergence of structural properties in typically developing children. During Stage I, typically developing children between the ages of 12 and 26 months are expected to begin expressing early semantic relations through word combinations (e.g., *mommy shoe, baby out*), and have an MLU between 1.00 and 2.00. Stage II states that children between 27-30 months are expected to have an MLU of 2.00-2.5, and begin using the prepositions *in* and *on*, as well as the morphemes *-ing* and plural *-s.* Stages III-V reflect the emergence of questions and negation, complex syntax, and mastery of grammatical morphemes. Although Brown's stages provide useful expectations for sentence length and the development of morphemes, the ability to produce diverse, simple sentences is not a hallmark of any stage (Ingram, 1989; Hadley, 2014).

To remedy this, Hadley (2014) recommended a shift towards a sentence-focused framework that critically examines developmental expectations for sentences, especially in clinical settings for children with language disorders. In fact, more recent investigations have focused on developmental expectations for simple sentences using a measure of sentence diversity. Sentence diversity operationalized as the number of different subject-verb combinations demonstrates the child's flexible use of those constituents, as well as the ability to generate more diverse combinations with development. In other words, as the sentences a child produces become more diverse, it is more likely the child is producing sentences by means of grammatical encoding rather than through rote memorization (cf., Hadley et al., 2018). By applying this measure to a sample of 40 typically developing toddlers, Hadley and colleagues determined diverse simple sentences should be expected by 30 months of age.

In order to examine how input facilitates the ability to produce diverse simple sentences, it is important explore input effects on children with readiness for producing childlike simple sentences, specifically children who have established an initial expressive vocabulary and who have begun to use word combinations, but are not readily producing simple sentences. By exploring input effects in a relatively a homogenous group of children at a similar developmental level, the potential for the child's language abilities to exert an influence on parent input will be reduced (Huttenlocher et al., 2010).

Interactive Features of Input

Interactive features can enhance the quality of input and support language learning. Creating an environment that is socially engaging not only motivates children to communicate with their partner, but increases the likelihood they will attend to the input. One important interactive feature is the parent's level of responsivity. Rooted in the social-interactionist theory of language learning, the responsivity hypothesis asserts that the best conditions for language learning are created when parent input hinges on the child's attentional focus and previous communicative turn (Girolametto et al., 1999). Children can not only detect when their parent responds to their own actions, but actively engage with responsive behaviors from their parent (Bigelow & Rochat, 2006). Maternal responsiveness can predict earlier instances of accelerated vocabulary growth, as well as the ability to combine words (Tamis-LeMonda, Bornstein, Hahana-Kalman, Baumwell, & Cyphers, 1998). Research studies examining responsivity have often identified temporally contingent, semantically related input as being optimal for maximizing the social engagement and language outcomes of the child.

Temporal Contingency

One important element of an interactive language learning environment is temporally contingent turns (Tamis-LeMonda & Bornstein, 2002). Turn-taking is critical within an interactive framework, because it ensures the child is receiving socially engaging reinforcement of their communication attempts. The prompt response to a child's communicative turn has been called "temporal contingency" to reflect the necessity of back and forth conversation. Temporal contingency has several important implications for language learning. When a child takes a verbal or non-verbal turn, they are signaling to their partner they have something interesting worth communicating about. Responding promptly to their communication attempt also increases the likelihood the child will be motivated to take another turn in the future. A temporally contingent response to a child's word, gesture, or vocalization also delivers an immediate model of adult-like language, and assists the child in mapping words to a referent in the environment (Tamis-LeMonda & Bornstein, 2002).

Literature addressing the temporal contingency of maternal speech has often focused on the immediate response of the parent (Tamis-LeMonda & Bornstein, 2002; Tamis-LeMonda, Bronstein, & Baumwell, 2001). However, balancing turns between children and adults is equally critical for language learners with an emerging syntactic system. Early in syntactic development, children may require more time to build syntactic representations for comprehending each incoming sentence. A parent may overwhelm his or her child's processing capacity if multiple sentences are presented in rapid succession. That is, the child may spend their cognitive energy processing the first utterance and miss the others entirely. This not only deprives the language learner of linguistic input which could strengthen their representation of syntactic structures, but also limits their ability to participate in conversation.

Evidence supporting balanced turns has stemmed from parent-implemented language interventions. Vulnerable language learners need more time to comprehend input sentences, and to respond to a communication partner. For this reason, reducing talkativity, or the sheer amount of parent turns, has been a focal point in parent-implemented interventions for children with language delays and disorders. For example, Hanen Programs (Weitzman, Girolametto, & Drake, 2017) teach parents to wait for their children to respond before taking a second verbal turn to promote balanced turn taking and to slow the pace of their speech to support children's comprehension. Other parent-implemented interventions such as Enhanced Milieu Teaching (EMT; Kaiser & Hampton, 2017) also encourage strategies such as mirroring and mapping and balanced turn taking to promote language development.

Both intervention approaches have demonstrated changes in parent input and improved language outcomes for children compared to control groups. Parents who received Hanen instruction reduced their total number of utterances and words per minute, and increased the number of multi-word combinations produced by children with expressive language delays post-intervention (Girolametto, Pearce, & Weitzman, 1996). Parents who received EMT instruction also were able to implement language facilitation strategies, and children post-intervention had higher receptive and expressive language skills when compared to control groups. Post-intervention, parents had better responsiveness, matched turns, and utilized more time delays to better create a well-timed language learning environment for their children (Roberts & Kaiser, 2015).

Semantic Relatedness

Another critical component to optimal interactive input is talking about objects and events related to the child's attentional focus. Semantically related responses address the importance of providing input that is concentrated on the child's object of attention (Girolametto et al., 1999). In other words, parents are encouraged to talk about the things that children are engaged with. This allows language learners to focus on comprehending input without having to expend cognitive energy redirecting their attentional focus and orienting to a new activity. Semantically related talk has a documented impact on the ease of learning new words (Tomasello & Farrar, 1986), the onset of a child's first 50 words (Tamis-LeMonda et al., 1998), and the production of word combinations (Girolametto et al., 1996; Nelson, Denninger, Bonvillian, Kaplan & Baker, 1984).

More recently, semantically related input has been found to predict language outcomes in several developmental periods. In a longitudinal investigation of how interactive input features relate to child language outcomes, Tamis-LeMonda and colleagues (2001) examined how responsive maternal speech predicted the achievement of early language milestones such as first imitations, 50 words produced, ability to combine words, and the ability to discuss past events. They discovered that both maternal responsiveness and the child's own communication behaviors predicted language milestones. However, maternal responsiveness predicted the emergence of language outcomes "over and above" the child's own behaviors. This suggests that it is not just the child's own communicative act that influences their ongoing development, but how parents are able to respond accordingly to their child's budding language skills. It is important to note that within Tamis-LeMonda et al.'s (2001) coding of responsive maternal utterances, semantically related and temporally contingent features were not coded separately, making it difficult to differentiate the impact of semantically related input on language outcomes relative to the impact of temporal contingency. Tamis-LeMonda et al. (2001) also did not examine how responsivity influenced the development of simple sentences by only looking at word combinations, which may or may not include sentences (e.g., *blue car, more juice*), and the later development of decontextualized talk. This current study focused exclusively on how interactive and other quality input features influence the child's transition to simple sentences, to analyze the contribution of responsivity on this linguistic milestone.

Linguistic Features of Input

The linguistic content of input has also been shown to support language learning. The sheer quantity of speech children hear has been related to greater vocabulary growth (Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991), as well as the growth of complex sentences (Huttenlocher, Vasilyeva, Cymerman & Levine, 2002). However, the quality of parent input can also drive significant changes in language outcomes. Different sentence types in child-directed speech can influence language development. For example, parent's use of imperatives, which have no subject and include uninflected verbs have been associated with slower child acquisition of grammatical structures (Newport, Gleitman, & Gleitman, 1977; Gleitman, Newport, & Gleitman, 1984). Fitzgerald, Hadley, and Rispoli (2013) also investigated how different sentence types associated with parent interaction style were related to linguistic features of input, specifically the input informativeness of tense and agreement morphemes in parent speech to their 21-month-old toddlers. A parent interaction style characterized by use of other-focused descriptive sentences was associated with more informative input for tense and agreement marking. Additionally, a directive parent interaction style composed of frequent direct directives (e.g., *come here*) was negatively associated with input informativeness. These findings indicate that parent interaction styles are systematically associated with different linguistic properties in the input children are exposed to.

Investigations into linguistic input have also focused on how diverse vocabulary and complex sentences influence language development. Rowe (2012) examined how parents' number of total words, different words, rare words, and decontextualized talk related to children's later vocabulary outcomes. In fact, lexical diversity and sophisticated vocabulary in the input related to child vocabulary at 30 months, and the use of decontextualized talk related to child vocabulary at 42 months, suggesting that as children gets older, exposure to various types of words and sentences is more beneficial than simply the number of total words. Huttenlocher, Vasilyeva, Waterfall, Vevea, and Hedges (2007, 2010) also examined the quality of input by conducting a longitudinal study examining the relation between parent's use of complex sentences and the acquisition of syntactic structure, and found that parents' use of more diverse complex sentences related to the number of complex sentences in child speech over the course of 14-30 months. However, Huttenlocher et al. (2007, 2010) only analyzed complex sentences and did not examine the contribution of simple input sentences, or how children's simple sentences developed longitudinally.

To address this gap, Rispoli, Hadley, and Simmons (2018) analyzed the contribution of diverse, simple sentences in parent input to child sentence diversity. Rispoli and colleagues emphasized how active declarative sentences with an overt subject and verb influenced the acquisition of that structure in children. Simple, active declarative sentences were hypothesized to be optimal for the transition to sentences for two reasons. First, exposure to diverse active declarative sentences is assumed to strengthen the child's representation of the clause in the mental grammar (Hadley et al., 2017). Second, by providing children with more evidence of different combinations of subjects and verbs, they receive necessary exposure to the various relations that different simple sentences can express. Therefore, it was predicted that diverse, active declarative simple sentences in the input would drive sentence diversity in children.

After analyzing the contribution of subject diversity, verb diversity, and sentence diversity in the input, only parent sentence diversity and the child's own lexical diversity were significantly related to the child's later ability to produce diverse simple sentences (Rispoli et al., 2018). This indicates that it is not just structurally specific lexical diversity that drives sentence development, but how subjects and verbs come together to generate diverse and unique utterances that strengthen a child's representation of syntactic structure, and the various relations they are able to express within a simple clause. Given these findings, it is hypothesized that simple sentences in the input are the most helpful for children beginning to build sentences.

Conceptually Supportive Features of Input

For infants and toddlers building a lexicon and developing sentence structure, conceptually supportive features of input should be highly contextualized, referring to objects and events present in the physical context (i.e., in the 'here and now'; Rowe & Snow, 2020). In naturalistic observations of parent-child interactions, episodes of joint attention increased the likelihood that mothers labeled concrete objects within the child's attentional focus, which in turn, was related to child vocabulary size (Tomasello & Farrar, 1986). More recently, Cartmill et al. (2013) found that parents' use of high-quality referentially transparent labels predicted children's vocabulary size three years later. As children get older, conceptually supportive high-quality input evolves as well to include topics of conversation that are more abstract. In fact, parent input that utilized decontextualized talk, or speech removed from the here and now, predicted kindergarten vocabulary abilities (Rowe, 2012), as well as language outcomes well into the school years (Uccelli, Demir-Lira, Rowe, Levine, & Goldin-Meadow, 2019).

Although investigators have examined how referentially transparent and decontextualized talk support language development in the early and later periods, there is only indirect evidence for how conceptually supportive input supports the transition to simple sentences. In a recent study, Hadley et al. (2017) taught parents two simple strategies known as 'toy talk' to enhance the quality of parent input sentences. These input modifications were designed to promote children's production of diverse, simple sentences. Parents were taught to "talk about the toys" their children were playing with and to "give the objects their names." The first strategy encouraged parents to use contextualized talk, while both strategies altered linguistic properties of parent input sentences. Hadley et al. (2017) found that toy talk instruction increased the number of noun subjects in parent input sentences, and parents' subject diversity was a significant predictor of children's growth in sentence diversity. However, all toy talk sentences referred to concrete objects in the play environment; thus, the toy talk coding scheme did not differentiate between conceptually and linguistically supportive features of input. In the current study, input removed from the 'here and how' was expected to be rare, since this study analyzed parent-child interactions in a play environment. Due to this, conceptually supportive input features were collapsed within the linguistic dimension. However, decontextualized and non-referential talk was coded separately from linguistic features of parent input and subsequently excluded, to identify how often input is not conceptually supportive at this developmental period.

Limitations to the unidimensional approach

Within each of these studies are clear impacts of how interactive, linguistic, and conceptually supportive features of input can support the transition from words to simple sentences. Despite this, these studies have often only examined that effect from the perspective of one of these three features. Interactive studies have not critically examined the linguistic content of input, and within investigations of linguistic input, it is unclear whether input was presented in an environment where the child was engaged and attentive. For example, one limitation of Tamis-LeMonda et al. (2001) is that within the category of broad descriptions, a description of an event, activity or object were all grouped together. No distinction was made between labeling an object (e.g., *this is a red apple*) and describing an activity (e.g., *you're spinning the top*), even though these are structurally very different. Labelling an object is important for learning new vocabulary words; however, it may be less helpful for learning how to construct a simple sentence. Given that responsive descriptions were found to be positively related to the early achievement of language milestones, it is unclear from the way they were grouped how each type of sentence drove the child's change in language development. Without examining the structural properties of input, the underlying linguistic mechanism that supports language learning is unclear.

The same critique is true of research on linguistic input. Neither Huttenlocher et al. (2007, 2010) or Rispoli et al. (2018) used a measure to determine whether the child's attention was focused on the parent input. Although Huttenlocher and colleagues (2007) stated that the researchers only analyzed child-directed speech to ensure the child was attentive to the input, they provided no explanation on how they determined whether the child was attentive. Even when the parent is directing a statement to the child, the child's attentional focus could be on an entirely different task. By solely investigating the linguistic content of parent input, it is not guaranteed that the child was focused enough to process the input. Even when studies have emphasized the importance of these three features of high-quality input, their measures have collapsed these features without analyzing their contribution separately. For example, by implementing toy talk, Hadley et al. (2017) integrated all three dimensions by teaching parents how to play and respond to their child, talk about toys in the play environment, and provide lexical noun subjects in the input. However, the measures used to examine parent input only looked at the conceptually supportive and linguistic features of input, making it difficult to determine whether parents crafted an interactive environment where the children were engaged and ready to attend to the input.

Only one study to date has examined two dimensions in a single study. Girolametto et al. (1999) examined the individual contribution of input characteristics supported by the responsive hypothesis and structural hypothesis to determine whether responsive or structural features were stronger predictors of children's language outcomes. Rather than investigate how these features facilitated language development collectively, Girolametto et al. analyzed responsive and structural input features separately, even after acknowledging the two hypotheses were compatible. This approach left the question of how these features work together unanswered. A multi-dimensional approach is therefore needed to deeply examine how interactive, linguistic and conceptual features of input work together to support the child's transition from words to simple sentences.

The multi-dimensional approach and language acquisition

This shift toward a multi-dimensional approach as outlined by Rowe and Snow (2020) is consistent with models of language acquisition that emphasize the importance of both extralinguistic processes such as memory and attention, and analyzable linguistic information. For example, Lidz and Gagliardi (2015) outline a model of how language learners process linguistic input to make predictions about the syntactic structure of their native language. This model has been adapted for the current study to provide a theoretical framework for how input sentences are processed to help build children's knowledge of their native language. See Figure 1 for a visual representation of this model. One important feature of this model is that it differentiates input from intake. Input is defined as the linguistic content from the environment, and intake is the important information extracted from the input. As input enters the language acquisition device, children use their extralinguistic processes such as memory and attention to filter out irrelevant environmental information, and reconstruct the linguistic content of that incoming sentence. After this, children can then use their developing grammar to assign parts of speech to words and build the syntactic structure of the sentence, via a process known as parsing. This reconstruction of only the linguistic information from the input, known as the perceptual intake, then feeds forward for grammatical analysis. During grammatical analysis, children compare the linguistic information extracted from the input sentence to their current knowledge of the syntactic system of their native language, and abstract representations of linguistic knowledge (i.e., Universal Grammar). After this cognitive comparison, children can update their grammar based on the information received, and use the more adult-like grammar to process future input sentences. From these updates, the children's developing linguistic system is strengthened and becomes more adult-like. The stronger the children's grammar, the more effortless and automatic their processing abilities become.

Interactive, conceptual, and linguistic features of input are all crucial elements to acquiring the syntactic structure of a language, and input may not be efficiently processed if a breakdown occurs in one or more features. For example, responsive and well-timed parent utterances give children space to filter out extraneous environmental information. A socially engaging environment allows children to more fully attend to the input without having to expend as much cognitive energy redirecting attention to a new activity. Interactive input is especially important during the early periods of language development, when children need more time to parse the input sentence and access the linguistic information that will help move their developing grammar forward. In the time it takes a strong adult-like grammar to process several sentences, a young child with a weaker syntactic system may still be encoding the first utterance. Thus, adequate pause time between parent utterances is hypothesized to be a critical feature of optimal input. Overloading the child's extralinguistic processes with consecutive utterances may increase the likelihood that children will construct a less complete representation of the first input sentence or be unable to construct subsequent ones entirely.

Optimal linguistic information is also needed to provide the child with the evidence they need to transition from words to simple sentences. A child who is just starting to acquire basic syntactic structure does not have the ability to process complex sentences automatically. This makes the role of simple input sentences important at this transition. Simple sentences are more likely to be analyzable by the child's developing grammar, and are less likely to overwhelm the child's capacity to process sentences. In addition, the more diverse, simple sentences the child is exposed to in the input, the stronger their linguistic processing abilities will become. From each sentence, the child will be able to accumulate evidence on how a basic clause in constructed in their native language, which will strengthen their ability to process and produce future sentences more efficiently.

Conceptually supportive features also work to enhance both these input processing phases. Contextualized input can provide the child with a more optimal opportunity to connect or map words in the input to referents in the environment, helping them infer the meaning of a word or sentence. Although the original Lidz and Gagliardi (2015) model does not address the child's developing lexicon, referentially transparent input is hypothesized to support the mapping process. In the adapted model seen in Figure 1, to comprehend an input sentence, the child must also learn and activate word meaning to derive the semantic meaning of sentences. Using contextualized talk rooted in the here and now supports the child's task of identifying what the words refer to, allocating more cognitive resources to be directed toward comprehension of sentence meaning and linguistic analysis. Therefore, to best make use of the child's language processing abilities, future investigations into the role of input should consider each of these features when examining how input can support language acquisition.

The current study

The purpose of this study was to characterize the number of optimal input sentences in child-directed speech, and to examine how those sentences support a child's transition to diverse, simple sentences. For this defined period of language development, the interactive and linguistic dimensions were the focal point in this study, since abstract input was expected to be rare. Optimal parent input was hypothesized as being 1) well-timed, 2) semantically related, 3) a well-formed simple, active declarative sentence and 4) contextualized. Each of these features were hypothesized to support the child's development of simple sentences by creating a socially engaging language learning environment, that would also provide linguistically rich input to support the child's development of syntactic structure.

Although it is clear that each of these features have impacts on language development, it was unknown how often they occur collectively in the input. In other words, it was unknown whether input can be interactive, but not linguistically rich, or whether it could be linguistically rich and not interactive. Therefore, the first aim of thesis was to identify how often these features converge during naturalistic parent-child interactions. This thesis also addressed how optimal input relates to child sentence diversity outcomes nine months later. Discovering the frequency with which these features co-occur and how they relate to sentence diversity can not only expand what is known about input variability and the child's transition to simple sentences, but can motivate discussions about how to best utilize these important features of input to support acquisition in vulnerable language learners. The following research questions were addressed:

1. How often do optimal interactive and linguistic features of input occur in parent input to slow typically developing 21-month-old toddlers?
2. How do parents vary in their use of optimal interactive and linguistic features of parent input to slow typically developing 21-month-old toddlers?
3. How do optimal interactive and linguistic features of parent input to 21-month-old toddlers relate to child production of simple sentences at 30 months?

It was hypothesized that parents who utilize optimal input features at 21 months would predict sentence diversity measures of children at 30 months, because input would not only be informative for learning the desired syntactic structure, but would also be presented in a responsive environment that can encourage the child's intake of linguistic information.

CHAPTER 2: METHODOLOGY

Archival Database

This thesis utilized archival data from a longitudinal study funded by the National Science Foundation (NSF; Rispoli & Hadley, 2008). Naturalistic parent-child interactions were collected every three months within a lab playroom setting to investigate the growth of tense and agreement in children between 21 and 36 months of age.

Participants were recruited from monolingual English-speaking households in the Champaign, Vermillion and Macon counties in Illinois. Participants were not eligible for the study if parents reported any neurological or sensory impairments, insertion of pressure equalization tubes resulting from chronic otitis media, or a delayed onset of walking or talking (i.e., after 15 months). To gather information regarding the child's general developmental milestones and language production, parent report checklists were obtained. *The Ages and Stages Questionnaire* (ASQ; Bricker & Squires, 1999) was used to screen for communication, fine motor, gross motor, social and cognitive development difficulties at 21 and 24 months of age. In addition, *the MacArthur-Bates Communicative Development Inventories: Words and Sentences* (CDI; Fenson et al., 2007) was used to collect information regarding the child's expressive vocabulary and use of grammatical markers at 21, 24, and 30 months of age.

In addition to parent reported checklists, two 30-min spontaneous language samples during free-play were obtained in the laboratory playroom at each measurement point from 21 to 36 months of age. During the first 30 minutes, parents were provided with age-appropriate toys and were instructed to "play as you would at home". During the second 30 minutes, an examiner joined the parent-child interaction to provide more opportunities for the child to different words and sentence types. Each session took place in the same playroom which included a play kitchen and table, a farm with animals and farmers, building blocks, a bowling set, puzzles and bubbles. Within cupboards and closets contained additional toys such as potatoheads, and baby dolls with a stroller and crib. Each playroom was set up in the same manner for each session and parents were encouraged to explore and play with any materials they wished. The same set-up of each play environment reduced the influence conversational topic could have on the language sample, as all participants were likely to discuss similar topics and toys.

This study utilized transcripts obtained from the archival database. All language samples were transcribed in the Systematic Analysis of Language Transcripts (SALT) software (Miller & Chapman, 2000) by a team of trained transcribers. All transcribers were required to complete approximately 20 hours of transcription training and acceptable levels of agreement for independent transcription of three consecutive language samples. Acceptable levels of agreement with the gold standard transcript was set at 90% for adult transcription and 80% for child transcription. Transcription of adult and child utterances was completed by separate research assistants from video and audio recordings. Transcribers were instructed to be conservative in their transcriptions and to listen to each utterance a maximum of 3 times to ensure they were accurate. A second transcriber then completed a consensus pass by re-listening to the recording. The consensus transcriber marked any words or morphemes as unintelligible if they could not confirm them. The consensus transcriber could also add any content words missed by the initial transcriber, but could not add any tense/agreement morphemes without agreement from a third transcriber. For further details on transcription, see Hadley, Rispoli, Holt, Fitzgerald, & Bahnsen (2014).

Participants

Participants in the current study were previously reported in Hsu et al. (2017). Participants in Hsu et al. (2017) were selected to be the same age and have a similar vocabulary size, mean length of utterance (MLU), and number of unique syntactic types (UST; Ingram, 1989). Because Hsu et al. (2017) analyzed how verbs used in parent input influenced later child verb diversity, children were chosen to be in the same broad stage of language development to reduce the child's influence on parent verb usage. For the current study, it was equally critical for participants to be homogenous. To examine how input facilitates the transition from words to simple sentences, it was important that all participants have comparable language abilities, since different features of input are important during different periods of language development (Rowe & Snow, 2020). Also, reducing variability among the child participant's language abilities limited the potential for bidirectional effects on parent input, because child language has been shown to influence parent input (Huttenlocher et al., 2010). Similarity in children's initial language abilities also reduced the potential relation between children's early and later language abilities, and increased the likelihood of observing effects of optimal parent input on children's subsequent sentence diversity.

At 21 months, all child participants had typical language development, but they were not readily combining words. Typical language development was determined based on (a) a passing score on the communication section of the ASQ (Bricker & Squires, 1999) at both 21 and 24 months, and (b) an expressive vocabulary at or above the 10^{th} percentile as measured by the CDI (Fenson et al., 2007) at 24 months of age. None of the participants had previously received early intervention services. All participants also had a small verb lexicon. Since Hsu et al. (2017) analyzed how verb diversity in the input related to later child verb diversity, only children who produced fewer than 10 action words based on the CDI at 21 months were included to ensure that children's verb use did not influence that of their parents. For the current study, this criteria further ensured that participants were at the same developmental level.

The 20 participants used a range of 37 to 208 total words (*M* = 77.05, *SD* = 39.78) based on the CDI. Participants also ranged in their number of different words between 5 and 41 (*M* = 21.20, *SD* = 11), based on their language samples. Each participant had at least one verb, ranging from 1 to 10 (*M* = 4.50, *SD* = 3.20), and at least one adjective ranging from 1 to 13 (*M* = 3.5, *SD* = 3.00). Twelve participants also had at least one preposition. By having a diverse vocabulary consisting of a variety of word classes, each participant possessed the necessary lexical items to make the transition to simple sentences during the period under study (i.e., 21 to 30 months).

Participants were mostly in the single-word stage, with MLUs ranging from 1 to 1.75 (M= 1.17, SD= 0.19). USTs ranged from 0 to 7 (M=2, SD= 2.2). Six participants did not produce any USTs. Five participants produced only a noun phrase (e.g., *a tree, my ball*). One participant produced one routine wh-question (e.g., *what's this*). Four participants produced USTs with a lexical verb phrase, and no subject. The remaining four participants all produced subject + verb sentences. One participant produced the sentence *baby eat*, the second participant produced the sentences *I sit* and *it beep*, the third participant produced *I eat* and *my poop* (which included a pronoun case error*),* and the fourth participant produced *bear eat* and *I did.* These participants all used high frequency verbs such as *eat*, and high frequency subjects such as *I.* The low number of unique subject+verb combinations exhibited by these four participants indicate they were not readily producing diverse simple sentences, and therefore were in the early period of this developmental milestone. See Table 1 for general child measures via language sample at 21 months.

Procedures

For the current study, additional information about the timing between utterances, and the child's non-verbal communicative turns were added to the archival transcripts in two passes. This additional information was needed to determine whether parent input sentences were in response to child communication, and/or paced with a sufficient pause between utterances to allow the child time to build a complete representation of the input sentence. On the first pass, the investigator or a trained transcriber added non-verbal communicative gestures to the existing transcripts by watching a video recording of the parent-child interaction. It was important the transcripts include non-verbal gestures, because they were counted as a child communicative turn. Non-verbal communicative gestures were operationalized as child point, show, give, reach gestures, shakes or nods of the head, or other conventional or symbolic gestures (see Appendix A).

On a second pass, a transcriber marked any points during the interaction that had a pause of ≥ 3 seconds. This information was important to determine whether or not the parent responded promptly to the child, or provided the child with a chance to initiate communication. The investigator or trained research assistant utilized a 60-bpm metronome and/or 60 bpm second timer to determine the length of each pause. Pauses were marked in the transcript with a semicolon (e.g., ;04) when a ≥ 3 second pause occurs between the same speaker (e.g., mother takes a second turn after waiting 4 seconds), or marked with a colon (e.g., :04) if the pause occurred between two different speakers (e.g., mother responds to child after waiting 4 seconds). If a child used a non-verbal communicative gesture *without* a verbal utterance, it counted as a turn, and not a pause:

M Cname, where is the bird?
C {points to bird}.

M the bird is flying.

If the child did *not* take a non-verbal communicative turn, then the time between the mother's utterances was counted as a pause:

M Cname, where is the bird?
; :04
M the bird is flying.

Parent input coding

The primary variable in this thesis was the number of parent utterances at 21 months that were interactive, conceptually appropriate, and possessed the linguistic structure hypothesized to facilitate diverse simple sentences. This variable was consistent with the construct of optimal input sentences currently under investigation as part of a Phase 2 clinical trial U01DC017135 funded by the National Institute of Health (NIH; Kaiser, Roberts, & Hadley, 2018). The following codes applied to all parent turns that were complete, intelligible, and contained a word or phrase. Interjections and sound effects were excluded from analysis.

Interactive Coding

Interactive parent input utterances were defined as semantically related and well-timed. The interactive coding scheme (see Appendix B) was designed to capture the number of responsive parent utterances that were semantically related to the child's attentional focus and well-timed between the parent and child. In addition, this coding scheme identified all utterances that were *not* interactive, by coding them for their exclusionary characteristics, such as being unrelated to the child's focus of attention or prior turn, or taking too many consecutive turns. Interactive coding was completed while watching video footage of the parent-child dyad.

If a parent utterance immediately responded to a child's verbal or nonverbal communicative turn, or a consecutive turn was taken after waiting more than 3 seconds, the parent utterance was coded as well-timed [WT]. Exclusionary codes were used to identify non-interactive features of parent utterances. If a parent utterance did not receive a [WT] code, it received an overlap code [OVERLAP], back-to-back [BB] code, or a temporally non-contingent [TNC] code. The overlap code was used for parent utterances that overlapped with the child utterance. This was thought to interrupt the child's ability to process the incoming parent utterance, because of the extra noise and confusion. Consecutive parent utterances with less than a 3-sec pause were coded as back-to-back utterances [BB]. Back-to-back utterances were not optimal, because they could negatively impact the child's ability to reconstruct and extract relevant linguistic information from the input (Lidz & Gagliardi, 2015). [BB] was also coded if the parent took a turn immediately following an instance of overlapping speech, without waiting 3-sec. However, there were four situations when the parent took two consecutive turns, and still received a [WT] code. In these situations, the two consecutive turns were not expected to increase the processing load for the child because of the first turn. First, [BB] was not coded if the first parent utterance was a social engagement word (e.g., *please, look, thank you, etc*.). The second exception was if the parent repeated a word or phrase produced by the child, and then put it into a sentence (e.g., *Dog. The dog is hungry*). This emphasized the child's own production and immediately provided them an adult-like model of input. [BB] was also not coded if the parent's first turn consisted of a single word, and their second utterance put that word into a sentence. The final exception was for contrastive subjects or predicates. If the parent took two turns to contrast a different predicate with the same subject (e.g., *This one is wet. This one is dry)* or a different subject with the same predicate (e.g., *Your pig is hungry. My pig is hungry too*), it was not coded as [BB], since the sentence structure was identical and only one sentence constituent is contrasted. The missed opportunity [MO] code was used for times when the parent did not respond to a child utterance. If the parent responded directly to the child more than three seconds after the child utterance, the temporally non-contingent [TNC] code was used. For example, if the child vocalized and pointed an object, and the parent labeled that object five seconds later, it received a [TNC] code. However, a parent could also miss an opportunity to respond to the child, but take a turn related to a new event or object in the environment. The parent's missed opportunity received a [MO] code, but their new utterance received a [WT] code:

> **C** {points to block}.
> **M** [MO].
> ; :04
> = C touches oven
> **M** the oven is hot [WT].

To be considered responsive, a parent utterance needed to also be semantically related to the child's attentional focus. This was defined as an utterance that directly related to something the child is focused on. For coding efficiency, semantically related utterances did not receive an extra code. Instead, it was calculated by subtracting unrelated utterances from the parents' total number of utterances. If a parent utterance was unrelated, it received an unrelated code [UR]. [UR] was used when the parent talked about a topic irrelevant to the child's attentional focus (e.g., the parent talks about blocks while the child is playing with the baby). [UR] was also used if the parent redirected the child's focus to a new activity.

Linguistic Coding

In contrast to Girolametto et al. (1999) which did not examine any sentence types in parent input, this study comprehensively coded each complete and intelligible parent utterance based on its structural features. These codes characterized the range of linguistic structures present in parent speech, to determine how structural features of input relate to the construct of responsivity. Each linguistic code was mutually exclusive. See Appendix C for how each linguistic code was operationalized. First, sentence types were identified based on if it was an active declarative sentence, question, or imperative. An active declarative sentence (ADS) was defined as a sentence where the subject appeared before the verb, the verb was in active voice as opposed to passive, and was a statement, not a command or question. An ADS consisted of a subject combining with a copula, or lexical verb. It was possible for an ADS to be simple, which was operationalized as a subject combined with one verb, or complex, where multiple verbs were present in the sentence. Simple, active declarative sentences were hypothesized as optimal for facilitating the child's own sentence development.

A simple, ADS was coded as [ADS:V] if it contained an overt subject, and lexical verb. The code [ADS:COP] was used for sentences with a copula that related a subject to an adjective phrase or prepositional phrase (e.g*., the ball is red; it's in*). If the sentence was a label, which was operationalized as a pronoun +copula +noun phrase (e.g., *that's a chicken; you're a girl, broccoli is a good vegetable*), it was be coded as [L:LAB]. In addition, stand-alone noun phrases that labelled an object (e.g., *blue shirt, apple*) were coded as [L:LABNP]. A label accompanied by a post-noun modifier (e*.g., that's a chicken over there*) received a [L:LABX] code. If the parent used a complex ADS that contained two verbs that composed of any combination of a copula and lexical verb, the code [L:CX] was used. An utterance was coded as [L:CP] if it contained a compound noun phrase, or compound verb phrase. If the parent reduced the structure of an active declarative sentence based on their variation or dialect, that utterance received a [RS] code. This was reserved for instances where the parent produced an utterance they could say to another adult during a casual conversation. For example, this code was used for features of non-standard dialects, and reduced copula or auxiliary BE for intonation only questions with a *you* subject (e.g., *you hungry? You cooking?).*

This coding scheme also identified different sentence types such as questions, and imperatives. A [L:YN] code was inserted for parent yes/no questions marked by a sentence-initial copula or auxiliary verb followed by the sentence subject (e.g., *do you want a cookie?).* A [L:WH] code was added to parent questions with movement of the WH- pronoun (i.e., what, when, where, how) and a copula or auxiliary verb to the sentence initial position, regardless of if they were simple or complex. Finally, imperatives were coded as [L:IMP], regardless if they were simple or complex. Imperatives are commands issued to the conversational partner or addressee, and have verbs in the uninflected or zero-form (e.g., *Johnny, come here; get the dog; let's build a tower*).

If an utterance was not an ADS, label, structural question, or imperative, it received an other [L:OTH] code. This included all miscellaneous utterance types that were not hypothesized as optimal for the transition from words to simple sentences such as single words that were not nouns, fragments, sentences with a moved locative (e.g., *there he goes; here comes the train*), passives (e.g., *the bone was eaten by the dog*), elided verb phrases and clauses (e.g., *I don't know*) and sentences with a reduced subject (e.g., *looks good, wanna cookie*?) that tended to appear in casual conversations.

Two exclusionary codes were used to exclude parent utterances that met the basic definition of an ADS, but did not provide optimal linguistic input. First, if an ADS contained an omission of an obligatory structure, such as an obligatory argument of the lexical verb or an obligatory tense/agreement morpheme, it was coded as ungrammatical [UG] (e.g., *he eat food*). Second, if the adult ADS was well-formed but did not align with the event in the play environment, a mismatch [MM] code was used. This included using a verb tense that did not match the timing of the event (e.g., saying *the train is coming down* long after it already has), using the incorrect verb (e.g. *she's eating water* when the parent meant drinking), or if the parent referred to themselves as Mommy/Daddy, or to their child by name instead of using a pronoun (e.g., *Mommy likes you; CName is hungry*). If an utterance happened to be both ungrammatical and have mismatch, then only [UG] was used, since mismatch was reserved for a sentences that were otherwise well-formed. For example, if an utterance was *Mommy eat cookie,* only the [UG] code was applied, because the sentence was not otherwise grammatical, despite the mismatch.

Conceptually Supportive Coding

Finally, this coding scheme excluded utterances that were not referentially transparent. At this developmental period, referentially transparent input was hypothesized as optimal to enhance the child's ability to map the language he or she hears to the physical environment. Decontextualized talk removed from the here and now has been linked to later language milestones such as complex syntax and upper-level vocabulary, but was not hypothesized to drive the child's transition to simple sentences. This coding scheme identified decontextualized input sentences referring to objects and events outside the "here and now." For the purposes of this study, contextualized input sentences were not coded separately, but rather folded into the linguistic code. This was done because we expected the vast majority of parent input sentences to be contextualized for two reasons. First, parents were instructed to play with their child as they would at home. This instruction was hypothesized to encourage contextualized talk, with relatively rare instances of decontextualized talk about events outside the play situation. Second, the role of conceptually supportive talk has been linked to the development of advanced vocabulary and complex syntax in the preschool years and not to the child's transition from single words to simple sentences. Therefore, this dimension was not a focus of the current study. However, adult sentences were excluded if they were not referentially transparent (Gillette, Gleitman, Gleitman, & Lederer, 1999; See Appendix D). To be identified as a referentially transparent sentence, both the subject and the predicate had to refer to specific objects and events in the play environment (Hadley et al., 2017). If a sentence subject did not refer to a concrete object in the play environment, it was coded as no referent [NR]. These did not support the child's ability to map word meaning to the physical environment, because the sentence subject referred to an abstract idea or activity that was not easily identified. These included sentences with an existential subject (e.g., *it's raining*), gerunds as subjects (e.g., *cooking is fun*), or abstract subjects that often referred to behavior (e.g., *it's ok; that's good*). Sentences that referred to people and events not in the play environment were coded as decontextualized [DC].

At minimum, each parent utterance contained one linguistic code and one interactive code. Each utterance, however, was coded exhaustively. If one utterance was not optimal for multiple reasons, each of those reasons were coded. For example, if an utterance was back-to-back, decontextualized, and mismatched, it received a code for each of those features:

C dog.
M that is a dog [WT] [L:LAB].
M You and Mommy are gonna play with grandma's dog tomorrow [BB] [DC] [L:MM].

Reliability

To ensure coding reliability, a second research assistant coded interactive and linguistic input. The second research assistant read the operational definitions and discussed any questions or comments with the investigator. The RA then coded one practice transcript completely and received feedback. A Cohen's kappa was used to compute reliability between the two coders. The criteria for reliability was set at .80, which is considered as an acceptable level of agreement

(Sprent & Smeeton, 2001). Due to the stay-at-home order placed by Governor Pritzker in response to the COVID-19 pandemic, the second transcriber was unable to access the videos to complete the interactive coding on the 30-minute transcripts. Instead, 5, 5-minute segment randomly chosen transcripts were coded for interactive features of input. The average kappa was .853 (*range* = .745-.922). Common errors included forgetting to include an [UR] code in addition to a timing code, forgetting to code for a [MO], and coding [BB] when greater than 3 seconds had passed. Linguistic coding was completed by the second transcriber on 4 (20%) randomly selected 30-minute transcripts. The average kappa was .936 (*range* = .912-.968). Common errors included not adding an additional [DC] or [NR] code, coding an utterance that had VP ellipsis as [ADS:V], and coding single verb imperatives (e.g., *look, watch*) as [L:OTH].

Outcome Measures

Parent input Measures

To quantify optimal input in child-directed speech at 21 months, the frequency of optimal input sentences were calculated for each 30-min language sample. An optimal input sentence was defined as a contextualized active declarative simple sentence that was semantically related and well-timed. This definition reflected the intersection of linguistic and interactive dimensions. The frequency of input sentences that possessed features of one dimension, but not another were also calculated. Therefore, the frequency of utterances in each of these four categories were calculated: (a) the number of parent utterances that were both interactive and linguistically optimal (*optimal input*), (b) the number of parent utterances that were interactive, but not linguistically ideal (*responsive input*), (c) the number of parent utterances that were linguistically ideal, but not interactive (*simple declaratives*), and (d) the number of parent utterances that were neither linguistically ideal nor interactive (*neither*). This identified how many input sentences contained the hypothesized optimal features, and simultaneously documented how these two variables interacted with one another. In addition, the total number complex sentences, labels, WH-questions, yes/no questions, imperatives, and other types of utterances were computed.

Child Sentence Diversity Measures

The second set of variables measured child sentence diversity at 30 months. Children's sentences have been previously coded in the archival database; however, prior measures of sentence diversity were operationally defined as spontaneous, unique combinations of an explicit subject with a lexical verb (Hadley, McKenna, & Rispoli, 2018). Copula *BE* as the main verb, or omissions of copula *BE* were not included, and subject-lexical verb combinations were allowed in structural questions with the exception of routine what-NP-doing and where-NP-going questions. The current study recomputed sentence diversity using the operational definition of Rispoli et al. (2018) and the ongoing Phase 2 clinical trial (U01DC017135). Children's sentence diversity were based on spontaneous, unique combinations of active declarative sentences with an explicit subject and a lexical verb, copula BE-adjective phrase, or copula BE-prepositional phrase. The presence of an overt copula BE form was required to meet the operational definition of a basic clause (i.e., subject + verb). Sentence diversity at 30 months was calculated by identifying the number of unique subjects combined with a unique lexical verb or overt copula. Only complete and intelligible utterances were analyzed. Subjects were required to be either a pronoun or lexical noun. If a child used a noun in both its singular and plural forms, or used the same root verb with different tense or agreement inflection, this was not counted as a unique sentence. Refer to Appendix E for the evolution of operational definitions for sentence diversity measures.

Analyses

Descriptive analyses were used to characterize individual differences in the interactive and linguistic properties of parent input sentences. Descriptive analyses were also used to characterize individual differences in children's measures of structurally-specific lexical diversity, including the number of different subjects with copula BE forms, different subjects with verbs, different lexical verbs, as well as the primary measure of sentence diversity (i.e., different subject-copula/verb combinations).

To address how interactive and linguistic features of input at 21 months relates to child sentence diversity at 30 months, partial correlations that controlled for the amount of parent talkativity were used. It was hypothesized that *optimal input* at 21 months that combined both ideal linguistic and interactive features would predict higher levels of child sentence diversity at 30 months.

CHAPTER 3: RESULTS

The purpose of this study was to investigate the intersection of interactive and linguistic features of parent input and to explore how combinations of these features related to children's sentence diversity. *Optimal input* was defined by the intersection of high-quality features in the two dimensions. For this study, responsive, active declarative sentences about objects and events in the physical context were considered optimal. It was hypothesized that parent use of optimal input at 21 months would be positively related to child sentence diversity at 30 months. This chapter will first describe linguistic and interactive characteristics of parent input. Next, descriptive analyses will characterize how often optimal interactive and linguistic features of input occur in child-directed speech, and how parents vary in their use of these features. Then, descriptive analyses of children's sentence diversity will be presented. This chapter will conclude with the correlational analyses exploring how optimal input related to child sentence diversity.

Parent General Measures

The total number of parent utterances, mean turn length, mean length of utterance in morphemes (MLU), and number of different words (NDW) at 21 months are reported in Table 2. Parents used an average of 422.2 utterances (*SD* = 108.64) during the 30-min sample, but varied considerably, with a range of 226 to 689 utterances. See Figure 2 for a box and whiskers plot of total parent utterances. Mean turn length reflects how many turns parents took in relation to their child. For every child turn, parents took an average of 2.6 turns (*SD* = .73). Parent MLU ranged from 2.57 to 4.74, with an average of 3.78 (*SD* = .60). Parents also varied in their lexical diversity (*range* = 161-368), with a mean of 239.55 different words per transcript (*SD* = 48.59).

Utterances that were not referentially transparent were excluded from analysis. This included utterances that were decontextualized and utterances that did not have a subject with a concrete referent. See Table 3 for the number of utterances within each transcript that were excluded. Decontextualized parent utterances were rare, with a mean of 3.95 utterances occurring in each transcript (*SD* = 4.29). Decontextualized utterances accounted for less than 1% of all parent utterances (i.e., mean decontextualized utterances divided by mean total number of utterances). One parent was an outlier. This parent used 17 decontextualized utterances during the 30-min sample. Subjects without concrete referents were also relatively rare (*M* = 8.5*; SD* = 6.76), accounting for approximately 2% of all parent utterances.

The frequency and variability of interactive and linguistic features in parent input

The first two research questions addressed the frequency and variability of interactive and linguistic features in parents' child-directed speech. Table 4 reports the linguistic structures parents used at 21 months. Recall that the primary linguistic structures of interest were active declarative sentences with a lexical verb or copula. The mean number of active declarative sentences with a lexical verb was 30.7 (*SD* = 13.30), and ranged from 11 to 58. Simple, active declaratives with a copula were less common, with a mean of 15 (*SD* = 7.91) and a range from 5 to 36. On average, simple active declarative sentences (average verb and copula ADS divided by average number of total parent utterances) accounted for 10.79% of parent utterances.

Parent use of different types of labeling varied. Noun phrases that labeled an object (e.g., *red apple*) had a mean of 45.35 (*SD* = 21.60) and ranged from 15 to 77. Utterances that labeled objects in a sentence (e.g., *that's an apple)* were less common, with a mean of 17.9, but also ranged widely from 3 to 49. Labels with a post-noun modifier (e.g., that's an apple in the box) were extremely rare, with parents averaging less than one per sample (*M* = .50; *SD* = .89).

The most frequently used linguistic code was *other*, which captured all non-noun single words, phrases, or miscellaneous sentences not captured by another code. The average was 112.95 (*SD* = 52.18). Utterances coded as *other* varied widely among parents, with a range of 52 to 237 utterances. Structural *yes/no* questions, WH questions, and imperatives were also relatively common, with averages of 57.5 (*SD* = 29.25), 53.50 (*SD* = 18.59), and 51.25 *(SD* = 42.88), respectively.

Utterances that had the structure of an active declarative sentence, but differed from the well-formed structure of an adult sentence were relatively uncommon among the parents. Utterances with reduced structure had a mean of 2.80 (*SD* = 2.71) and a range from 0 to 10. Utterances that were coded as mismatch (i.e., utterance form did not align with the event) were also rare with a mean of 4 (*SD* = 3.57) and a range of 0 to 12. Utterances that were ungrammatical had a wider range from 0 to 21, and a mean of 5.4 (*SD* = 5.84). To illustrate the variability among parents, box and whisker plots are displayed for each code in Figure 3.

Table 5 reports interactive features of parent utterances. Recall that optimal interactive utterances were temporally contingent on the child's previous turn or after waiting, and were semantically related to what the child was doing. Temporal features of utterances were coded exhaustively as well-timed, back-to-back, overlapping, or temporally non-contingent. In addition, a missed opportunity to respond to the child was also coded. The most commonly used temporal codes were well-timed and back-to-back. Parent utterances that were well-timed ranged from 135 to 326, with a mean of 226.3 (*SD* = 43.14), accounting for approximately 53% of utterances. If an utterance was not well-timed, it was most often back-to-back. Parents had an average of 178.95 (*SD* = 78.09) back-to-back utterances, which corresponded to 42% of parent utterances. However, back-to back utterances ranged considerably from 54 to 393. Other codes that addressed the temporal qualities of parent turns were less common, with missed opportunities, overlap, and temporally non-contingent utterances averaging 20.7 (*SD* = 10.19), 14.9 (*SD* =11.23), and 1.4 (*SD* = 1.05), respectively. Semantically related utterances were extremely common, accounting for approximately 97% of parent utterances (*M* = 411.05, *SD* = 109.68). Utterances received a code if they were unrelated to the child's attentional focus. Unrelated utterances were relatively rare, with a mean of 11.15 *(SD* = 12.24) and a range of 0 to 49. Therefore, if parents were *not* responsive, it was most often because they took consecutive turns, not because they were trying to shift the child's focus. See Figure 4 for box and whisker plots for each type of interactive code.

Table 6 provides the frequency, percentage of total utterances, mean, and standard deviation for parent utterances that were both interactive and linguistically optimal (*optimal*), only interactive *(responsive), only* linguistically optimal (*simple declarative*), or neither interactive nor linguistically optimal (*neither*) for each participant. The number of utterances coded as *optimal* (e.g., a well-timed, related simple active declarative sentence) was relatively rare (*M* = 16.75, *SD* = 7.70). On average, these utterances accounted for approximately 4% of parent utterances, ranging from 1 % to 8%. Utterances that were *simple declaratives* only (e.g., a back-to-back ADS or unrelated simple ADS) also made up a small number of the input sentences (*M* = 21.25, *SD* = 9.44). A large number of parent utterances were *responsive* only (e.g., a well-timed and related question, imperative, other, etc.). The average number of *responsive* utterances was 198.65 (*SD* = 39.82), corresponding to approximately 48% of parent utterances. Finally, parent utterances that *neither* type of high quality features (e.g., a back-to-back or unrelated question, imperative, other, etc.) were common with a mean of 168.65 (*SD* = 77.25). There was considerable variability in parent utterances with low-quality features, with 22% to 56% of parents' total utterances characterized by this combination. Figure 5 illustrates the distribution of these various combinations through a box and whisker plot. As seen in the figures, the vast majority of parent utterances are categorized as *responsive* and *neither*, indicating that simple, active declarative sentences that were also responsive made up a small portion of parent utterances.

Child General Measures

Table 7 provides each child participant's subject diversity, verb diversity, and sentence diversity at 30 months. Recall that only active declarative sentences that consisted minimally of an (a) explicit subject and lexical verb, or (b) explicit subject, copula, and an adjectival or prepositional phrase were included. Participants used an average of 8.05 different subjects (*SD* = 3.33), and 15.8 different verbs (*SD* = 5.56) in the 30-min sample. This indicates that children used fewer different subjects than verbs at 30 months. Subject diversity ranged from 1 to 14, and verb diversity ranged between 1 to 25. Child sentence diversity, which was the primary outcome variable of this study, ranged from 1 to 47. On average, children produced 23.35 unique sentences at 30 months (*SD* = 10.34).

Relation between parent input features and child sentence diversity

The third research question explored the relation between linguistic and interactive features of parent input with child sentence diversity nine months later. It was hypothesized that parent input that possessed optimal linguistic and interactive features at 21 months would be related to child sentence diversity at 30 months. One-tailed correlations were used to examine whether these measures of parent input and child sentence diversity were related. The total number of parent utterances was partialled out to control for differences in parent talkativity (i.e., how much the parents talked overall) when examining the relations between the different combinations of input features and child sentence diversity.

No significant relation was found between parent use of *optimal input* sentences and child sentence diversity (r = .231, p = .170). In addition, no significant relation was found between parent use of *simple declarative*s with child sentence diversity (r = .171, p = .243), or *responsive* utterances with child sentence diversity (r = .275, p = .127). However, a significant negative relation was found between parent utterances with low-quality features (i.e., *neither*) and child sentence diversity (r = -.435, p = .031). That is, even after controlling for parent talkativity, as parents' use of *neither* utterances increased, child sentence diversity decreased.

In summary, the following trends were revealed. There was considerable variability in parents' use of linguistic and interactive input features. As a whole, parents used a small number of simple, active declarative sentences in child directed speech, accounting for approximately 5% of parent utterances. In contrast, utterances with high-quality interactive features were common among participants. However, if a parent utterance was *not* responsive, it was usually because the parent took too many consecutive turns. When examining the intersection of interactive and linguistic input features, parents most often used child-directed speech that was *neither,* or *responsive*. Input sentences that were simple declaratives, or optimal for both dimensions were relatively rare, accounting for approximately 5% and 4% of the input sentences, respectively. In addition, no significant relation was found between *optimal input* at 21 months and child sentence diversity at 30 months, but a significant negative relation was found between input that possessed *neither* optimal linguistic or interactive features and child sentence diversity.

CHAPTER 4: DISCUSSION

The primary purpose of this study was to examine how various dimensions of input quality interacted in child-directed speech. Input quality was defined through a multi-dimensional approach that integrated features from linguistic, interactive, and conceptual dimensions (Rowe & Snow, 2020). Previous studies had investigated input from a single dimension only, highlighting either the linguistic or interactive dimensions. This study is the first to identify how different features *within* each dimension interact with one another in parent input.

A second objective of this study was to investigate whether *optimal input*, operationalized as the intersection of ideal interactive and linguistic features, contributed to children's development of diverse, simple sentences. Responsive parent input has been associated with developmental milestones such as the first 50 words in expressive language, and the onset of word combinations (Tamis-LeMonda et al., 2001). In addition, the number of different simple, active declarative sentences in parent input has been associated with children's sentence diversity nine months later (Rispoli et al., 2018). Therefore, in this study, parents' use of simple active declarative sentences presented during responsive conversational interaction were hypothesized to contribute children's development of simple sentences.

The first research question addressed how frequently the different dimensions converged in child-directed speech. Because decontextualized and non-referential talk was hypothesized to be rare, this study focused specifically on the interaction between the interactive and linguistic dimensions in contextualized talk. Four combinations were possible. An utterance could contain ideal linguistical features, but lack the ideal interactive features (*simple declaratives*), ideal interactive features but not ideal linguistic features (*responsive input*), both ideal interactive and linguistic features (*optimal input*), or neither ideal interactive nor linguistic features (*neither*). *Optimal input* was the rarest combination. Although simple declarative sentences provide the most transparent model of how a subject and predicate combine to form a sentence, these sentences accounted for only 5% of the parents' total utterances. In comparison, *responsive* parent input was the most common intersection in child directed-speech, accounting for approximately 48% of total parent utterances. This indicates that parents were much more likely to be responsive than to provide their child an adult-like model of a simple sentence. In addition, approximately 40% of the input possessed *neither* optimal interactive nor linguistic features. *Neither* was largely made up of back-to-back single words, phrases, imperatives and questions. This suggests that not only does parent input have few declaratives, but for some parents, it consists of consecutive communicative turns with little wait time.

The second research question investigated how much variability existed between parents' use of interactive and linguistic features. Parents' use of *responsive* input ranged widely from approximately 28% to 65%, and their use of *neither* from 22% to 56% of utterances. Back-to-back turns were the most common reason that an utterance was not ideal interactively. Parents varied widely in their tendency to take too many turns without providing the child adequate time (i.e., 3 sec) to formulate a response. In contrast, *optimal input* was rare across parents, ranging between 1% and 7 % of parent utterances.

The third research question examined the relation between the intersections of the linguistic and interactive dimensions, and children's development of diverse, simple sentences. Controlling for the total number of parent utterances, no significant relation was observed between parent utterances with *optimal input* features and child sentence diversity at 30 months. On the other hand, a significant negative relation was observed between parent utterances that lacked optimal input features and child's sentence diversity. The total number of parent utterances that were not responsive nor declarative were negatively associated with child sentence diversity nine months later. Utterances classified as *neither* were diverse in their linguistic features (e.g., questions, imperatives, phrases); however, they shared a common interactive feature. The overwhelming majority of these utterances were coded as back-to-back, or consecutive parent utterances without adequate wait time. For some parents, more than half of their child-directed speech was back-to-back. This not only prevented the child from taking a communicative turn, but may have hindered the child's ability to efficiently process valuable information from the input (Lidz & Gagliardi, 2015).

Although it was hypothesized that *optimal input* would facilitate child sentence diversity, these results suggest that reducing the number of parent utterances without optimal input features is as important as increasing the presence of the utterances that possess them. Given the limited number of simple, active declarative sentences observed and the limited variability among parents, the non-significant relation observed between parent *optimal input* utterances and children's sentence diversity is not surprising, and raises questions for how this intersection can be increased in child-directed speech. Still, it is clear that on the rare occasions when *optimal input* does happen, it is imperative the child is given time to comprehend what has been presented. If that input sentence is immediately followed by a number of questions or imperatives, it is less likely that the child would be able to fully process that first sentence as they try to shift their attention and cognitive energy to the incoming flow of consecutive utterances. Therefore, considering how to reduce the amount of *neither* in parent input is an important first step. Then, increasing the presence of well-timed simple declaratives would be a necessary next step. Together, these modifications to parent input may have a positive impact on child sentence development.

Connections to Previous Literature

The negative relation observed between parent utterances that were neither responsive, nor in the form of active, declarative sentences with children's sentence diversity align with previous investigations that examined how linguistic features of parent input influenced child language outcomes. Hadley, Rispoli, Fitzgerald, and Bahnsen (2011) investigated how the frequency of overt and ambiguous evidence for tense marking in parent input related to children's growth of tense marking. Although no positive relation was observed between the frequency of overt evidence for tense marking and children's growth, the frequency of ambiguous evidence for tense marking in the input was negatively associated with morphosyntactic growth. In the current study, a negative relation was also revealed between parent use of *neither* utterances and child sentence diversity. Taken together, these findings underscore the importance of considering how to reduce input features associated with slower child growth, not just increasing input features associated with faster child growth. For example, intervention strategies that reduce consecutive parent turns would seem to be a good place to begin.

Previous studies investigating interactive parent input have found positive relations between responsiveness and outcome measures such as vocabulary growth (Girolametto et al., 1996; Tamis-LeMonda et al., 2001). However, in this study, no relation was found between *responsive* parent input and child outcomes when sentence diversity was the outcome measure. These mixed findings emphasize the importance of defining a clear developmental period when investigating relations between input characteristics and outcomes. What is important for one developmental period may not have the same impact during another. For example, learning vocabulary requires the child to map a word to an object or event. Responsive input may help drive the acquisition of that skill. However, responsivity alone appears less helpful for promoting child sentence diversity. That is, learning how to create diverse simple sentences may be facilitated by input sentences made up of diverse combinations of subjects and predicates (Rispoli et al., 2018). In moving research on optimal input forward, we must consider how the linguistic characteristics of input work in conjunction with interactive features to promote children's transitions from one developmental period to another.

Although previous studies have documented positive relations between linguistic features of parent input and child sentence diversity (Hadley et al., 2017; Rispoli et al., 2018), this was not observed in the current study. To reconcile the differences in findings, it is important to recognize the methodological differences between studies. First, each of these studies possessed a different sample size. Hadley et al. (2017) was the largest, with 38 parent-child pairs. Rispoli et al. (2018) had a smaller sample size with 27 participant families. The current study included 20 participant families, making it the smallest study of the three. It is possible that the sample size of this investigation was too small to detect the input effects observed in larger samples.

Second, the three studies also analyzed linguistic input differently. The current study examined the frequency of responsive simple sentences in the input whereas Rispoli et al. (2018) and Hadley et al. (2017) focused on the diversity of specific structures in parent input. Rispoli et al. (2018) measured the number of different subject+verb combinations in simple sentences, and Hadley et al. (2017) measured the number of different noun subjects in active declarative sentences. These studies focused on the effects of structurally specific lexical diversity because the diversity of subject-predicate combinations in the input helps make the underlying structure of a simple clause more salient to a child by highlighting them as separate constituents (cf. Hadley et al., 2017). However, this study did not explore the potential input benefits of structurally-specific lexical diversity, which may have contributed to the lack of significant findings between *optimal input* and child sentence diversity. Future research exploring the contribution of parent input and child sentence diversity should combine responsivity with measures of input sentence diversity rather than the frequency of active, declarative sentences alone. For example, studies should examine the benefits of diverse noun subjects or diverse subject-verb combinations in active declarative sentences.

Third, both the current study and Rispoli et al. (2018) shared the same observational design that analyzed input during a naturalistic parent-child interaction. In comparison, Hadley et al. (2017), was an intervention study. Parents were provided strategies designed to increase their responsivity and to use more optimal linguistic features by using toy talk. They were taught to 'talk about the toys' and other objects physically present in the play room, and to 'give the objects their names.' Following this instruction, parents receiving toy talk instruction increased their use of noun subjects in simple sentences relative to parents in a quasi-control group. The observational nature of the current study likely contributed to the limited variability observed in parent use of declarative sentences and the absence of input effects between the rare optimal input sentences and child outcomes. An intervention study that increases the amount of responsive and diverse active declarative sentences may provide the child more salient evidence of how subjects and verbs combine in their native language, and subsequently influence their sentence development.

Finally, the parent input variable of this study differed from previous studies. The innovative aspect of this study was its integration of both the interactive and linguistic dimensions in the input variable. In contrast, Rispoli and colleagues (2018) only examined the linguistic features of input in their study. Although the intervention in Hadley et al. (2017) taught parents to be responsive and talk about objects in the physical environment, the input variable combined only the linguistic (i.e., the diversity of noun subjects in declarative sentences) and conceptual dimensions. Future intervention studies are needed to better understand the unique and shared contributions of responsive and linguistic features of input to child sentence diversity. Moving forward, investigations into parent input and child sentence diversity should retain the multi-dimensional approach of the current study, and incorporate structurally-specific lexical diversity measures of both parent input and child outcome measures. Exploring high-quality input across multiple dimensions may be better to identify the most critical features or combination of features that can facilitate or slow down a child's transition from one developmental period to another.

Future Directions for Clinical Research

Future investigations into optimal input properties should investigate the ways in which individual features of input work separately and/or together to support development during a specific period. Critically examining how these different input features can best support a desired outcome is a necessary step forward from studies that have grouped various sentence types together due to their communicative function, rather than their structural properties (e.g., Tamis-LeMonda, 2001). In this study, responsivity coupled with specific linguistic input features were hypothesized to influence the child's ability to combine different subjects and predicates. A similar framework can be used to examine how input features across dimensions support vocabulary learning. For the current study, sentence labels (e.g., *that's a bear*) were coded separately for other simple active declarative sentences because while they are helpful for mapping a noun to an object, they do not deliver information about an event or quality of a subject. However, looking at how sentence labels can work with responsive input features may be a valuable endeavor for understanding how the intersection of these features can support a child's acquisition of new words.

Investigating the linguistic characteristics of expansions would also be a useful area of inquiry. Expansions are inherently responsive, in that the child's own utterance is immediately followed with an adult-like utterance that contains and adds on to the child's prior utterance. Still, no studies to date have examined how the structural properties of an expansion can facilitate the child's use of sentences. It is unknown whether an expansion that uses the child's word as the subject or predicate of a simple sentence is any better than an expansion that builds the child's word into a phrase. Analyses that examine how parents expand their children's single words may highlight the linguistic features of expansions most beneficial to sentence development.

Furthermore, it is important to consider how children's own behaviors influence the input directed towards them. It may be more difficult for a parent to use descriptive, declarative sentences with a child who is unable to coordinate and sustain joint engagement in play (Barrera, 2020). Similarly, a child who has mature social engagement skills may better direct the interaction towards events within the play environment they find engaging and increase the likelihood that they make use of the content in parent input utterances. Future work should consider how interactive and linguistic features in parent utterances can be shaped by the child to better understand the dynamic and complex relation between input and language development.

Rowe and Snow's (2020) multi-dimensional framework for studying features of input and the findings of this study also provide insights for parent-implemented interventions. For children who have language disorders, acquiring their native language is a struggle due to underlying biological and/or developmental factors, regardless of their environment. The abundance of *neither* and exceptionally rare nature of *optimal input* sentences delivers a clear message for the sequence in which parent strategies can be taught. Coaching parents to first wait for a response and balance their turns can increase the child's opportunities to comprehend and respond to what has been said. Regardless of how linguistically rich an input sentence is, it may not be helpful to a child who is in the midst of processing a prior input utterance. However, the current study has illustrated that responsive input alone is not sufficient to facilitate sentence diversity. Once an interactive language-learning environment has been established, it is important to teach parents how to provide high-quality linguistic input that delivers diverse models the structure their child is ready to acquire. Doing so would increase the amount of *optimal input*, and therefore provide the child with more explicit evidence for how simple sentences are built. In fact, a Phase 2 clinical trial U01DC017135 (NIH; Kaiser, Roberts, & Hadley, 2018) is currently underway, designed to maximize outcomes for children with developmental language disorder by teaching parents strategies to deliver responsive input containing simple declaratives that will support children's syntactic development. By using these strategies, it is hypothesized that parents will not only increase their wait time but will increase the number of diverse, simple declaratives as they are taught to capitalize on comment-worthy moments.

Although the original hypothesis was not supported by the results of this study, valuable information about how parent input features contribute to child sentence diversity was still revealed. This was the first study to examine input properties from a multi-dimensional approach and relate them to a clearly defined developmental period. Only through the intersection of the interactive and linguistic dimensions was the negative relation between *neither* and child sentence diversity revealed, as well as how little parent input contains declaratives in contrast to the large number of responsive utterances. Moving forward, inquiries into the role of input in language learning must not only consider what is optimal at that point in the child's development, but also how various features intersect to support a child's transition from one period to another. Future studies that examine input from a multi-dimensional approach can provide a useful framework for understanding variation in specific features of input and the effects of specific input properties on children's language growth and developmental outcomes.

CHAPTER 5: FIGURES

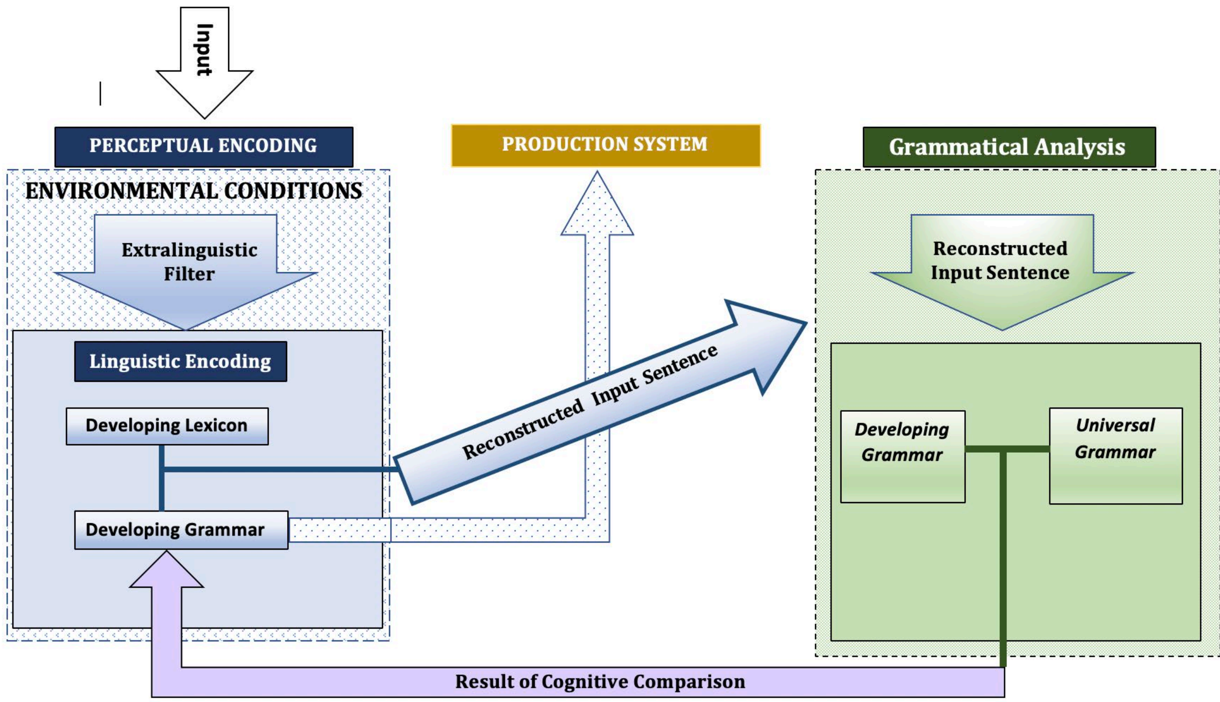

Figure 1. Language Acquisition Device model adapted from Lidz and Gagliardi (2015).

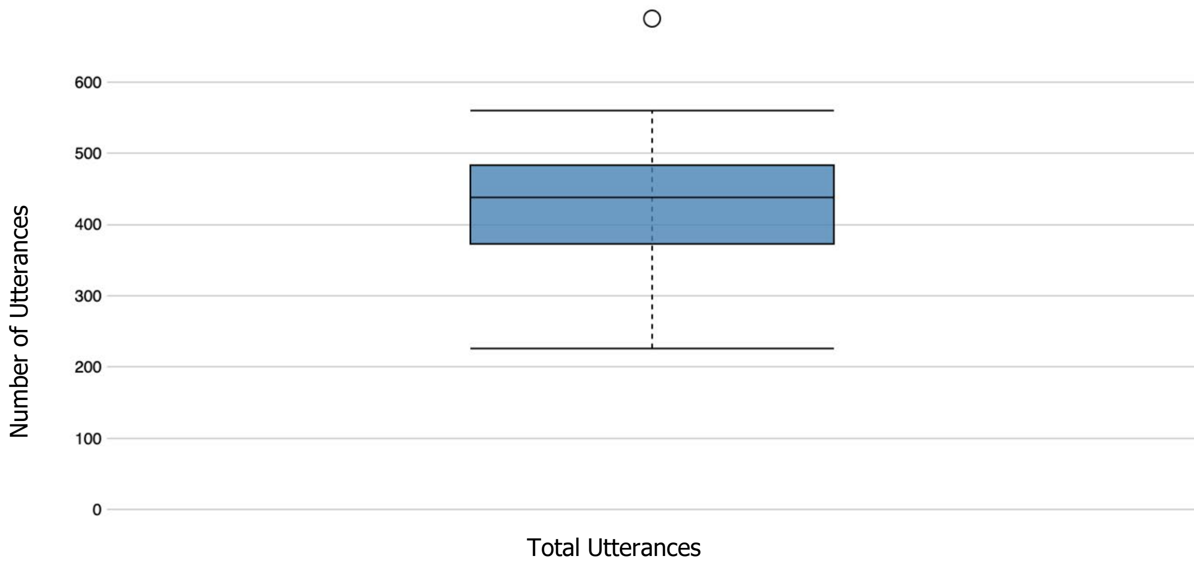

Figure 2. Box and whiskers plot of total parent utterances.

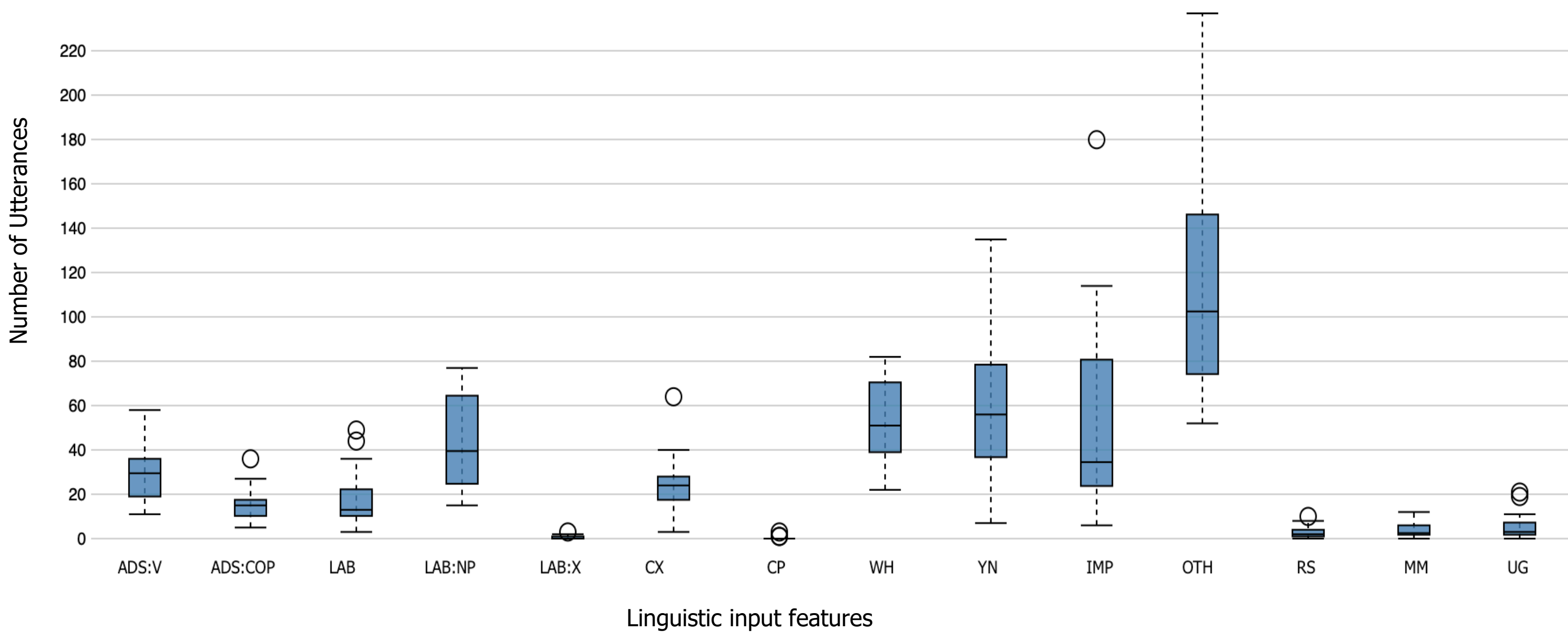

Figure 3. Box and whiskers plot of parent linguistic input features at 21 months.

Note. ADS:V= active declarative with lexical verb, ADS:COP= active declarative with copula, LAB=label, NP LAB= Noun Phrase Label, LABX= label with post modifier, CX= complex declarative, CP= compound structure, WH= structural WH question, YN= structural yes/no question, IMP= imperative, OTH= other, RS= reduced structure, MM=mismatch, UG=ungrammatical

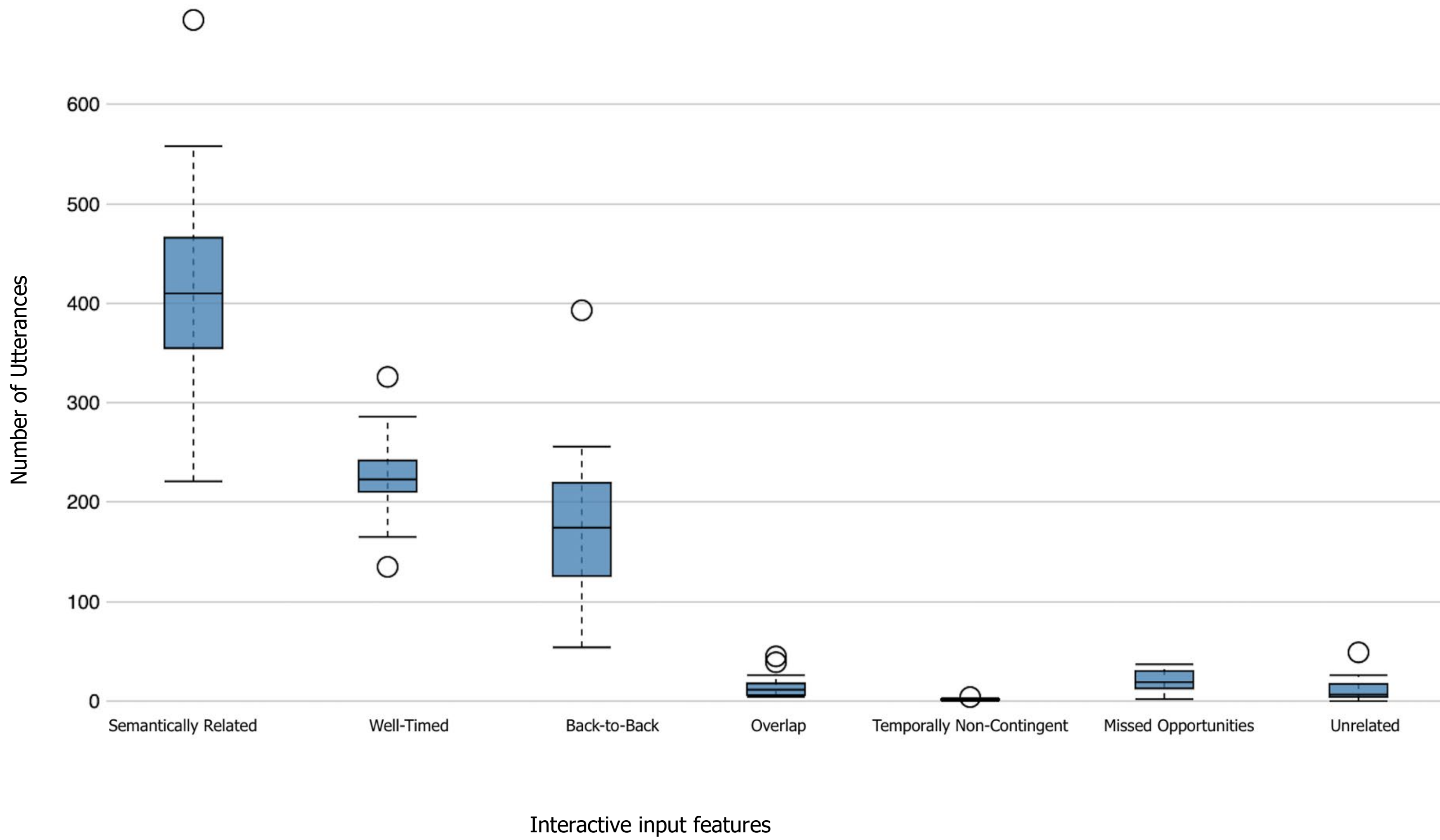

Figure 4. Box and whiskers plot of parent interactive codes at 21 months.

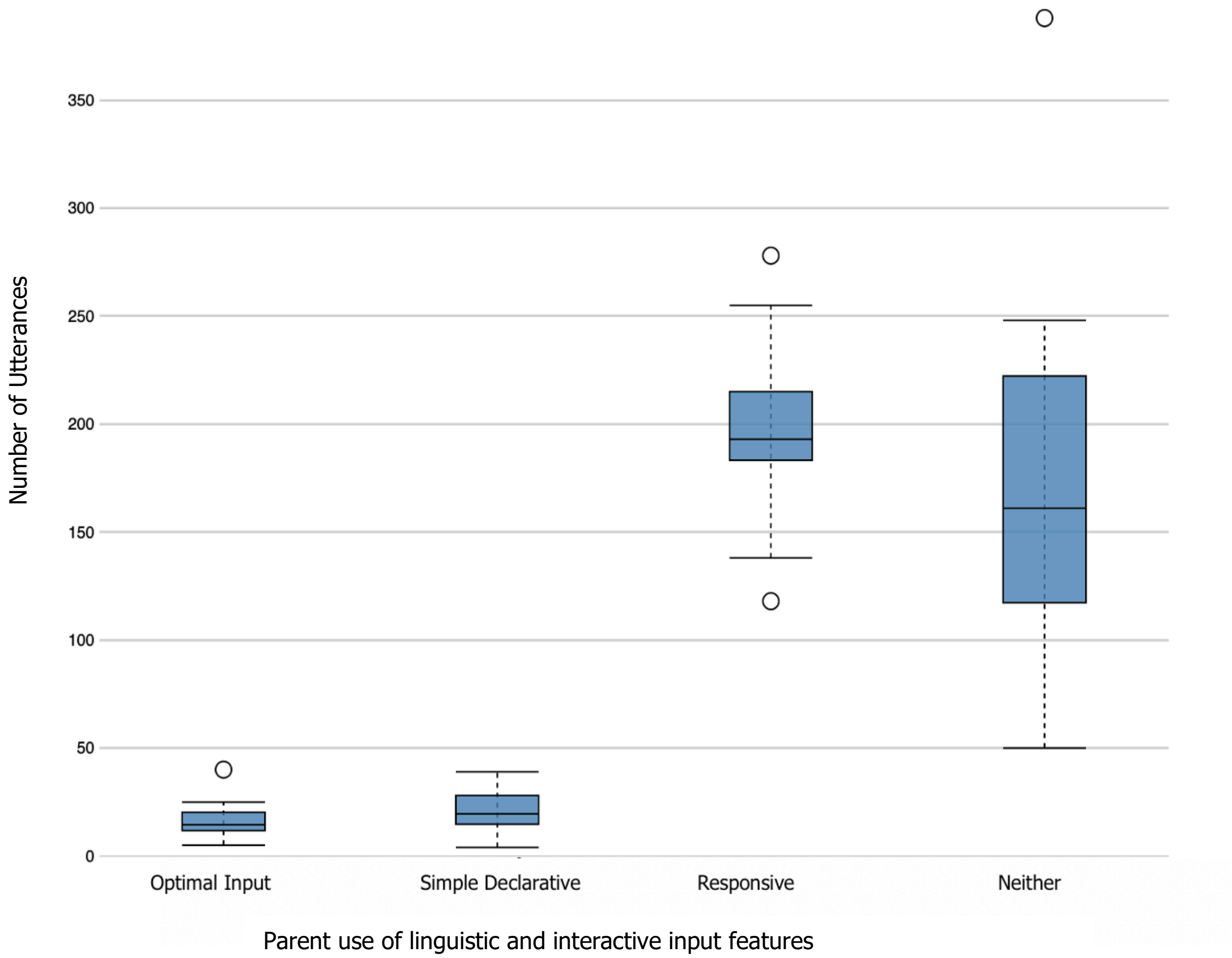

Figure 5. Box and whiskers plot of parent intersections of linguistic and interactive features at 21 months.

CHAPTER 6: TABLES

Table 1

Child General Measures at 21 Months

Participant	%Intelligibility	NTW	NDW	MeanTurnUtt
GTP06B	0.39	110	37	1.28
GTP10G	0.07	12	5	1.48
GTP13B	0.24	32	15	1.27
GTP14B	0.21	62	15	1.60
GTP18B	0.65	153	35	1.22
GTP21B	0.55	96	31	1.21
GTP22B	0.35	59	8	1.08
GTP26B	0.22	64	30	1.45
GTP28G	0.47	113	41	1.40
GTP30B	0.41	115	24	1.14
GTP36B	0.55	132	14	1.24
GTP40B	0.11	18	14	1.11
GTP44B	0.56	227	24	1.27
GTP45G	0.46	108	34	1.25
GTP47B	0.32	38	16	1.09
GTP51G	0.41	135	24	1.25
GTP54B	0.32	46	8	1.27
GTP55G	0.45	73	28	1.18
GTP56B	0.08	21	8	1.28
GTP57B	0.26	39	13	1.21
Mean	0.35	82.65	21.20	1.26
SD	0.17	54.63	11	0.13
Minimum	0.07	12	5	1.08
Maximum	0.65	227	41	1.60

Note. %Intelligibility= percent intelligibility*,* NTW= total number of words, NDW= number of different words, MeanTurnUtt= mean turn length in utterances

Table 2

General Parent Input Measures

Participant	Total Utt	MeanTurnUtt	MLUm	NDW
GTP06B	360	2.15	4.53	244
GTP10G	231	1.89	4.09	202
GTP13B	451	3.88	2.80	184
GTP14B	484	2.42	2.57	161
GTP18B	389	2.06	3.58	229
GTP21B	289	2.08	4.52	268
GTP22B	443	2.90	4.05	238
GTP26B	336	1.72	3.88	220
GTP28G	226	1.82	3.74	174
GTP30B	510	2.01	4.74	368
GTP36B	433	2.51	3.69	232
GTP40B	689	4.22	3.05	256
GTP44B	501	1.82	3.75	283
GTP45G	388	2.45	3.16	174
GTP47B	390	3.35	3.91	253
GTP51G	560	2.40	4.49	292
GTP54B	447	2.88	4.01	244
GTP55G	377	2.59	4.19	252
GTP56B	457	3.07	3.14	229
GTP57B	483	3.73	3.65	288
Mean	422.20	2.60	3.78	239.55
SD	108.64	0.73	0.60	48.59
Minimum	226	1.72	2.57	161
Maximum	689	4.22	4.74	368

Note. Total Utt= total utterances, MeanTurnUtt= mean turn length in utterances, MLUm= mean length of utterance in morphemes, NDW= number of different words

Table 3.
Decontextualized and Non Referential Parent Utterances at 21 Months

Participant	Decontextualized	No Referent
GTP06B	4	10
GTP10G	0	7
GTP13B	1	23
GTP14B	0	0
GTP18B	5	13
GTP21B	8	16
GTP22B	1	25
GTP26B	5	4
GTP28G	3	7
GTP30B	17	8
GTP36B	0	4
GTP40B	5	7
GTP44B	8	5
GTP45G	0	2
GTP47B	5	3
GTP51G	0	8
GTP54B	8	5
GTP55G	7	12
GTP56B	0	0
GTP57B	2	11
Mean	3.95	8.50
SD	4.29	6.76
Minimum	0	0
Maximum	17	25

Table 4

Parent use of linguistic types at 21 months

	Optimal Input		*Labels*			*Other Linguistic Types*								
Participant	ADS:V	ADS:COP	LAB	NP LAB	LABX	CX	CP	WH	YN	IMP	OTH	RS	MM	UG
GTP06B 21P	23	19	13	39	0	22	0	70	83	20	54	0	12	5
GTP10G 21P	15	15	8	15	0	19	0	48	42	14	53	1	0	0
GTP13B 21P	19	36	19	62	0	3	0	72	30	89	104	5	6	8
GTP14B 21P	11	15	28	73	0	11	0	63	7	180	77	0	0	19
GTP18B 21P	35	15	3	63	0	24	0	40	52	34	107	4	4	7
GTP21B 21P	19	24	13	40	2	23	0	69	35	6	52	1	2	3
GTP22B 21P	31	27	17	25	0	16	0	82	78	37	124	3	2	0
GTP26B 21P	28	5	8	64	0	18	0	36	68	35	66	1	4	3
GTP28G 21P	28	5	5	27	1	14	0	27	46	9	61	0	2	2
GTP30B 21P	44	11	23	68	1	64	3	73	80	32	95	1	12	1
GTP36B 21P	35	16	12	56	0	24	0	42	49	80	105	1	7	3
GTP40B 21P	28	13	44	76	0	40	0	59	80	88	237	4	1	21
GTP44B 21P	58	17	36	66	3	27	0	22	36	41	191	1	1	3
GTP45G 21P	14	7	8	34	0	15	0	48	37	114	101	3	2	5
GTP47B 21P	32	8	49	22	0	28	0	31	60	54	91	8	5	2
GTP51G 21P	50	13	22	20	1	32	0	75	135	24	169	4	3	11
GTP54B 21P	54	16	11	33	0	26	0	54	62	31	144	3	6	8
GTP55G 21P	18	11	12	23	2	28	0	78	86	23	87	1	8	0
GTP56B 21P	36	5	15	77	0	26	1	33	15	83	153	10	1	1
GTP57B 21P	36	22	12	24	0	35	1	48	73	31	188	5	2	6
Mean	30.70	15.00	17.90	45.35	0.50	24.75	0.25	53.50	57.70	51.25	112.95	2.80	4.00	5.40
SD	13.30	7.91	12.59	21.60	0.89	12.57	0.72	18.59	29.25	42.88	52.18	2.71	3.57	5.84
Minimum	11	5	3	15	0	3	0	22	7	6	52	0	0	0
Maximum	58	36	49	77	3	64	3	82	135	180	237	10	12	21

Note 1. ADS:V= active declarative with lexical verb, ADS:COP= active declarative with copula, LAB=label, NP LAB= Noun Phrase Label, LABX= label with post modifier, CX= complex declarative, CP= compound structure, WH= structural WH question, YN= structural yes/no question, IMP= imperative, OTH= other, RS= reduced structure, MM=mismatch, UG=ungrammatical

Note 2. Green= optimal input feature, yellow= neutral input feature, red= unhelpful input feature

Table 5

Parent use of interactive codes at 21 months

			Temporal Features				Semantic Features
Participant	SR	WT	BB	OVERLAP	TNC	MO	UR
GTP06B 21P	334	220	133	5	3	32	26
GTP10G 21P	231	135	84	10	2	33	0
GTP13B 21P	444	191	255	4	1	10	7
GTP14B 21P	466	236	227	20	2	19	18
GTP18B 21P	383	251	125	10	2	28	6
GTP21B 21P	285	172	104	11	2	24	4
GTP22B 21P	394	226	209	6	2	15	49
GTP26B 21P	327	233	81	17	2	19	9
GTP28G 21P	221	165	54	6	1	35	5
GTP30B 21P	506	286	186	39	0	9	4
GTP36B 21P	426	211	203	15	4	37	7
GTP40B 21P	685	270	393	25	0	2	4
GTP44B 21P	499	326	161	13	0	30	2
GTP45G 21P	362	217	162	6	1	31	26
GTP47B 21P	366	220	163	5	1	12	24
GTP51G 21P	558	268	244	45	0	19	2
GTP54B 21P	447	239	196	10	2	7	0
GTP55G 21P	368	238	126	12	1	19	9
GTP56B 21P	453	209	217	26	1	20	4
GTP57B 21P	466	213	256	13	1	13	17
Mean	411.05	226.30	178.95	14.90	1.40	20.70	11.15
SD	109.68	43.14	78.09	11.23	1.05	10.19	12.24
Minimum	221	135	54	4	0	2	0
Maximum	685	326	393	45	4	37	49

Note 1. SR= semantically related, WT= well-timed, BB= back-to-back, TNC= temporally non-contingent, MO= missed opportunities, UR= unrelated

Note 2. Green= optimal input feature, red= unhelpful input feature

Table 6

Frequency and Percentage of Parent Input Intersections at 21 months

		Frequency of Intersections				*Percent of Intersections*			
Participant	Total Utt	Optimal Input	Simple Declaratives	Responsive	Neither	Optimal Input	Simple Declaratives	Responsive	Neither
GTP06B	360	20	18	178	119	5.56%	5.00%	49.44%	33.06%
GTP10G	231	11	12	118	83	4.76%	5.19%	51.08%	35.93%
GTP13B	451	13	18	172	223	2.88%	3.99%	38.14%	49.45%
GTP14B	484	12	14	212	235	2.48%	2.89%	43.80%	48.55%
GTP18B	389	21	15	221	112	5.40%	3.86%	56.81%	28.79%
GTP21B	289	14	21	145	86	4.84%	7.27%	50.17%	29.76%
GTP22B	443	5	29	190	178	1.13%	6.55%	42.89%	40.18%
GTP26B	336	14	15	205	87	4.17%	4.46%	61.01%	25.89%
GTP28G	226	18	9	138	50	7.96%	3.98%	61.06%	22.12%
GTP30B	510	22	25	251	186	4.31%	4.90%	49.22%	36.47%
GTP36B	433	20	28	186	192	4.62%	6.47%	42.96%	44.34%
GTP40B	689	9	25	255	388	1.31%	3.63%	37.01%	56.31%
GTP44B	501	40	28	278	140	7.98%	5.59%	55.49%	27.94%
GTP45G	388	10	11	194	160	2.58%	2.84%	50.00%	41.24%
GTP47B	390	20	18	187	146	5.13%	4.62%	47.95%	37.44%
GTP51G	560	23	37	244	248	4.11%	6.61%	43.57%	44.29%
GTP54B	447	25	39	209	162	5.59%	8.72%	46.76%	36.24%
GTP55G	377	9	4	213	125	2.39%	1.06%	56.50%	33.16%
GTP56B	457	14	27	192	222	3.06%	5.91%	42.01%	48.58%
GTP57B	483	15	32	185	231	3.11%	6.63%	38.30%	47.83%
Mean	422.20	16.75	21.25	198.65	168.65	4.17%	5.01%	48.21%	38.38%
SD	108.64	7.70	9.44	39.82	77.25	1.87%	1.78%	7.27%	9.14%
Minimum	226	5	4	118	50	1.13%	1.06%	37.01%	22.12%
Maximum	689	40	39	278	388	7.98%	8.72%	61.06%	56.31%

Note. Green= both optimal features present, yellow= one optimal feature present, red= neither optimal input feature present

Table 7
Child measures of subject, verb, and sentence diversity at 30 months

Participant	Subject Diversity	Verb Diversity	Sentence Diversity
GTP06B	4	20	25
GTP10G	11	12	18
GTP13B	4	12	13
GTP14B	5	18	19
GTP18B	8	19	27
GTP21B	10	22	37
GTP22B	5	17	19
GTP26B	10	17	32
GTP28G	10	13	18
GTP30B	13	19	32
GTP36B	8	12	21
GTP40B	5	10	13
GTP44B	11	20	27
GTP45G	7	8	12
GTP47B	8	16	28
GTP51G	7	15	17
GTP54B	14	20	26
GTP55G	9	20	33
GTP56B	1	1	1
GTP57B	11	25	47
Mean	8.05	15.80	23.25
SD	3.33	5.56	10.34
Minimum	1	1	1
Maximum	14	25	47

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APPENDIX A: COMMUNICATIVE GESTURES

GESTURE	OPERATIONAL DEFINITION
POINT	• When the child points to something with clear communicative intent (e.g., points and looks at parent, point in response to parent's question, point occurring with voc/word) • To be considered a point, child must either have an outstretched index finger, or open hand. The point can touch the object, such as if the child points to a picture in the book, or uses an index finger to touch an object.
SHOW	• Child holds up item in front of parent while looking at parent. May or may not be accompanied by a verbal turn.
REACH	• When child looks at parent and/or vocalizes while reaching for something their ***partner is holding*** or to request the partner's assistance obtaining the object that is out of reach • When child reaches in response to a choice question • To be considered a reach child must outstretch hand and extend arm out to attempt to get desired object or request action from partner. • NOT considered reach if child **takes** object independently
GIVE	• When child hands something to the parent with clear communicative intent (e.g., looks to parent and/or vocalizes to request help with item) • Do NOT count as a give if child gives an item to a toy (e.g., a bottle to the baby)
GRAB	• The child grabs something out of the adult's hand that the adult was showing, or did not have any intention of giving them. • **Cannot** be in response to the adult giving them an object. • **NOT** considered a grab if the child takes something in front of the adult, or on the table
NOD/SHAKE HEAD	• When child nods or shakes head to indicate yes/no in response to a choice question posed by the parent
WAVES (FOR HI/BYE)	• When child waves as a greeting of hi or bye
SIGNS	• When child uses sign language (e.g. *more, eat, potty*)
COMMUNICATIVE GESTURE	• When child uses an iconic gesture with communicative intent (e.g., hands under head for 'sleep', blows on pretend food to indicate 'hot,' upturned hands and shrugged shoulders to indicate 'where' with a look to the parent). Iconic gestures depict attributes of referents or events, such as their shape, function, movement, etc.

Adapted from: Romano, Kaiser, Lounds-Taylor & Woods (2019); Kaiser, Roberts, & Hadley (2018)

APPENDIX B: INTERACTIVE CODING SCHEME

CODE	OPERATIONAL DEFINITION	EXAMPLE
Well-Timed [WT]	This code is used when the adult takes a turn that is either: 1. Within 3 seconds of the child's previous turn 2. After waiting at least 3 seconds between their previous turn as does not meet any of the exceptions outlined in the [BB] code (see below).	C xxx. M you want the ball [WT]. M that looks fun. ; :04 M you want the train [WT]?
Unrelated [UR]	This code is used for an adult turn that does not relate to the child's object of attention. This would include the parent discussing a play set in the room that the child's attention is not focused on. Do NOT use this code if the parent introduces a new toy into the play, such as putting a new animal in the farm, or giving a baby a new bottle. Also, this code is for broad shifts in attention. This means that the parent should not be penalized if their utterance is related to the play, but the child's eye gaze is elsewhere, or if the child's attention briefly shifts away, but they come right back to the play.	C {points to tower}. M this kitchen is cool [UR]. C Horsie is eating. M look. M the cow is eating, too → assign [SR] code, because is related to the activity

Back-to-Back [BB]	This code is used for a consecutive adult turn without providing the child a chance to respond. This is operationalized as less than or equal to 3 seconds. There are 4 exceptions. [BB] is not coded when: 1. The adult *imitates* a single word or phrase the child says, and then puts that word or phrase into a sentence 2. The adult uses a single word, phrase, or sentence in Utterance 1, followed by specific use of one of puts the word or phrase into a sentence (i.e., sentence expansion) 3. The adult uses Utterance 1 and 2 to illustrate a contrasting syntactic structure such as: a. contrasts the subject NP or VP of Utterance 1 in Utterance 2 b. contrasts the object NP label of Utterance 1 in Utterance 2 4. The adult utterance follows a turn for attention/ engagement. This includes: a. A turn for attention (e.g., look, see, CName) b. A turn for engagement (e.g., sound effects)	C my turn. M it's your turn to ride the train [WT]. M make sure to be careful [BB]. C ice cream. M ice cream [WT]. M you want some ice cream [WT]. M ball. M the ball is red [WT]. M this cup is wet [WT]. M this cup is dry [WT]. M Look, Cname [WT]. M that ball is red [WT].
Overlap [OVERLAP]	This code is defined as an adult turn that overlaps with a child utterance. This is marked in the transcript by <>.	C <the cookies>. M <those cookies are> for you [OVERLAP]. M <is this> a book [OVERLAP]? C <no book please>.

Temporally non-contingent [TNC]	This code is defined as an adult turn that comes more than 3 seconds (3.01 + seconds) after the previous child's turn that **directly responds** to the child's communicative turn. This could include responding late to a question, labeling an object the child pointed to late, or responding to a comment too late.	C what that? : :05 M that's a ball [TNC]. C so fun. : :04 M this is really fun, isn't it? C {points to box}. ; :04 M that's a box.
Missed Opportunity [MO]	This code is defined to illustrate a point where the parent did not respond to the child's communicative turn at all. It is possible that a parent could miss an opportunity to respond, wait 3+ seconds, and then say an utterance that could be well-timed.	C xxx. C {points to ball} M {} [MO]. C that. M {} [MO]. C cookie. M {} [MO] ; :03 M {oh} you found the spoon [WT] → this is well-timed because the parent has still waited 3 seconds, and has brought up a new topic of conversation. The parent's lack of response to the child saying 'cookie' is reflected in the [MO] code.

APPENDIX C: LINGUISTIC CODING SCHEME

CODE	OPERATIONAL DEFINITION	EXAMPLE
Simple Active Declarative Sentence [ADS:V]	This code is used for sentences that meet the following criteria and contain only (1) lexical verb. **An active declarative sentence contains:** 1. a subject noun phrase appears before the main verb or auxiliary 2. The verb phrase is in active voice. 3. the sentence is a statement, not a command or structural question (an intonation only question, that structurally is an ADS is permissible) 4. The sentence cannot be an embedded non-finite clause, or 'to' infinitive clause	M the ball is rolling [ADS:V]. M I saw the bear [ADS:V]. M you want a cookie [ADS:V]?
Subject+Copula+Adjective or Preposition [ADS:COP]	This code is used for a sentence where a subject combines with a copula to assign a descriptor or location word to a referent. This code *excludes* copula sentences that label an object (see L:ILP)	M The house is so big [ADS:COP] ! M it's in [ADS:COP]. M you're silly [ADS:COP].
Label [L:LAB]	This code is used for a sentence that labels an object. It contains: 1. A pronominal subject 2. Copula 'is' 3. noun to identify an object.	M That's a ball [L:LAB]. M it's a chicken [L:LAB].
NP Label [L:LABNP]	This code is used for anytime the parent uses a noun phrase to label an object NOT in a sentence. This could be: 1) Single word 2) Modifier+noun 3) Article+modifier +noun	M ketchup [L:LABNP]. M the blue cup [L:LABNP] M some milk [L:LABNP]?

Label [L:LABX]	This code is used for a sentence that labels an object. It contains: 1. Pronominal subject**(not here or there, see [L:OTH)** 2. Copula 'is' or 'are' 3. NP 4. An additional phrase modifying the NP	M That's a lid for a pot. M that's a stroller with a baby. That's a chair for me.
Complex Sentence [L:CX]	This code is used for an active declarative sentence that contains (2) main verbs excluding compound verb phrases. This could include any combination of a copula and lexical verb, including sentences with infinitival *to* constructions, serial verbs, non-finite clausal complements, finite clausal complements, and relative clauses.	M you wanna go to the kitchen [L:CX]? M I think he wants a prize [L:CX]. M That's the girl who ate the pizza [L:CX].
Compound Sentence [L:CP]	This code is used for a sentence containing a compound noun phrase or a sentence containing a compound verb phrase.	M We are singing and dancing [L:CP]. M The dog and the cat are playing together [L:CP]
Reduced Structure [RS]	This code is used for an adult active declarative sentence that has reduced the structure of a sentence, meaning they have optionally included some feature that is typically marked in Mainstream American English. A [RS] sentence should be perfectly acceptable in the speaker's dialect if they were talking casually to an adult friend. This could include grammatical features of non-standard dialects, or omitted copula or auxiliary BE in intonation questions that have a you subject.	M you got apples [RS]? M you hungry [RS]? M and this one fit in that one [RS]. → in AAE dialects, marking of regular 3rd person present tense can be optional
WH-Questions [L:WH]	This code is used for a question beginning with who what, when, where, how, why	M what are you doing [L:WH]? M who ate the cookie [L:WH]?

Yes/No question [L:YN]	**This code is used for a question with a fronted auxiliary verb such as 'is' or 'do' that is typically answered with a 'yes' or 'no'.**	**M Do you want the puzzle [L:YN]?** **M Is the baby sleeping [L:YN]?**
Imperative [L:IMP]	This code is used for a sentence that functions as a command. It is characterized by an uninflected verb, and the optional presence of an addressee term.	M Put the baby to bed [L:IMP]. M Don't drink that juice [L:IMP]. M Cname, come here, please [L:IMP].
Other [L:OTH]	This code is used for miscellaneous utterance types. It includes: 1. Sentences that have locative movement 2. Single words 3. Fragments 4. Social greetings/expressions 5. Elided VP or CP 6. Reduced subject sentences	M here it comes [L:OTH]. M apple [L:OTH]. M in the barn [L:OTH]. M great job [L:OTH]. M I don't know [L:OTH]. M wanna play [L:OTH]?
Ungrammatical [L:UG]	This code is used when an active declarative sentence contains ungrammatical sentence structure, such as omitting an obligatory context necessary in adult-like speech. This includes omitting tense/agreement markers that are not optional in the speaker's dialect, or articles.	M He want sleep [L:UG]. M ball is rolling [L:UG]. M you want build the tower [L:UG]?
Mismatch [L:MM]	This code is used when an active declarative sentence does not align with the play scene. This could include: 1. Parent refers to him/herself as 'Mommy' or 'Daddy' or to the child by CName when they mean "you". 2. The wrong verb has been used 3. The form of the sentence (tense/aspect) does not align with the event.	M Mommy wants the blue cup [L:MM]. M CName likes it [L:MM]. = C puts cup to mouth M you're eating [L:MM]. = ball rolls down a slide. M The ball is rolling [L:MM].

APPENDIX D: CONCEPTUAL CODING SCHEME

CODE	OPERATIONAL DEFINITION	EXAMPLE
No Referent [NR]	This code is used when an adult turn utilized a subject that does not have a concrete referent. This includes: *1.* Gerunds used as subjects (e.g., *cooking is fun, sleeping is boring)* 2. Existential subjects where the subject does not refer to a concrete object (e.g*., it's raining, it's my turn to ride the bik*e) 3. Non-concrete subjects, that that typically refer to behaviors *(e.g., that's ok, that's not nice*)	M cooking is fun [NR]. M it's raining [NR]. M that's ok [NR].
Decontextualized [DC]	This code is used for an adult turn whose subject is a concrete referent, but is not present in the play environment and/or is not in the here and now. This includes the parent talking about a person or object not in the room, or referring to a past event.	M We have a puzzle like this at home [DC]. M you played with this at Grandma's, remember [DC]?

APPENDIX E: SENTENCE DIVERSITY MEASURE AND CODING HISTORY

STUDY	VARIABLE	OPERATIONAL DEFINITION	EXCLUSIONS
Hadley (1999)	Unique Syntactic Types (USTs)	Unique combinations of two or more words containing syntactic status that formulate a phrase. Does not include greetings (e.g., hello), social engagement words (e.g., please), interjections (e.g., uhoh), addreesee (e.g., Mommy) and yes/no.	Imitations, partially unintelligible, interrupted, or abandoned utterances.
Mckenna (2013)	Unique subject-verb combinations (USVs)	Active declarative sentences with an explicit subject and lexical verb. Also included non-formulaic structural questions.	Followed Hadley (1999) and excluded imperatives, sentences with conversational partner names as subjects, and routine do and go questions
Rispoli et al. (2018)	Unique subject-verb combinations (USVs)	Unique subject+verb combinations with an overt subject and main verb produced in active declarative sentences. Also included existential *there* and *here* used with copula (e.g., there it goes)	Followed Hadley (1999) and excluded imperatives, structural questions.
The Current Study	Unique subject-verb combinations	Unique subject+verb combinations with an overt subject and lexical verb or overt copula produced in active declarative sentences.	Followed Rispoli et al. (2018), and existential *there* and *here* sentences used with a copula.

Adapted from McKenna (2013)